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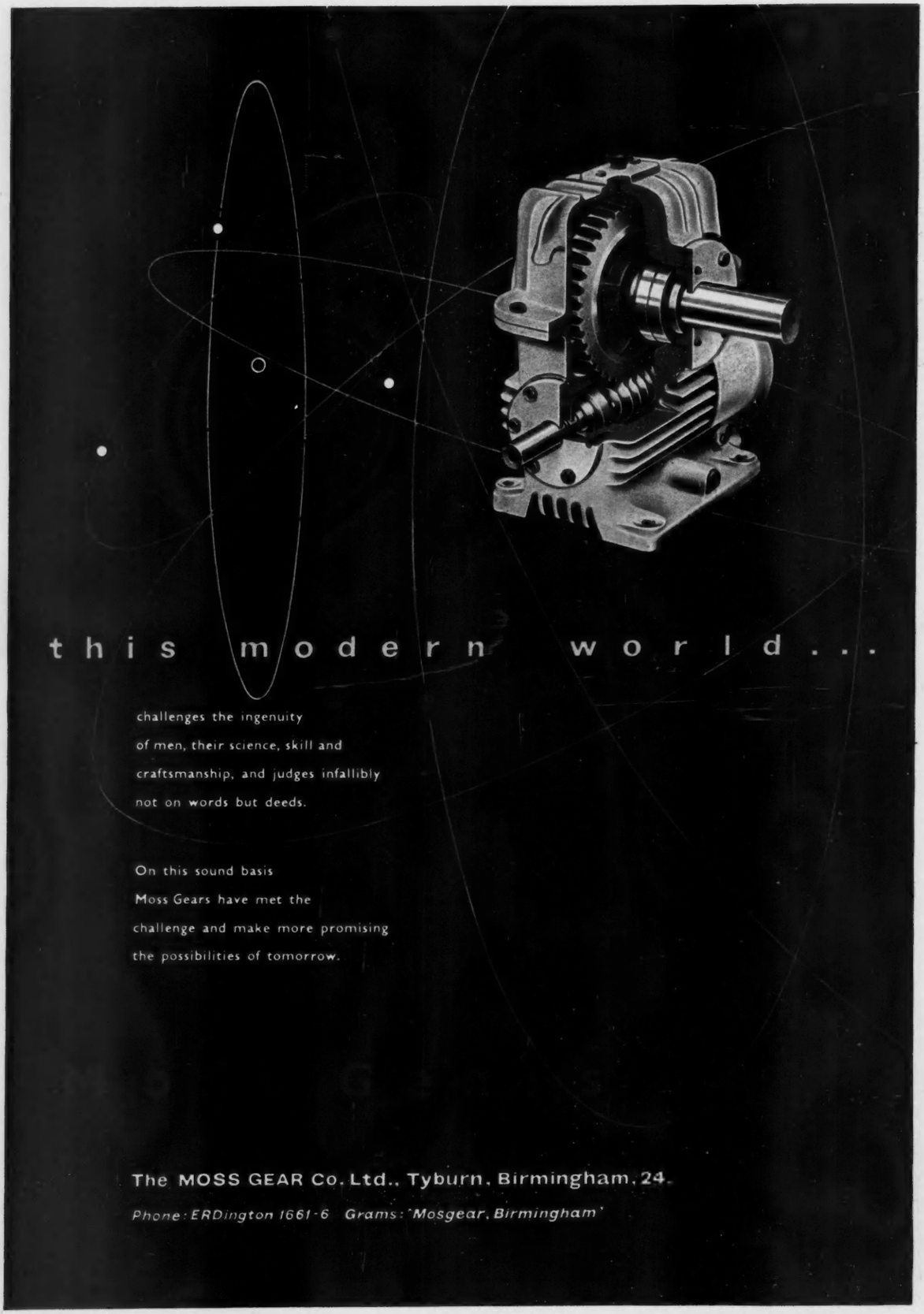
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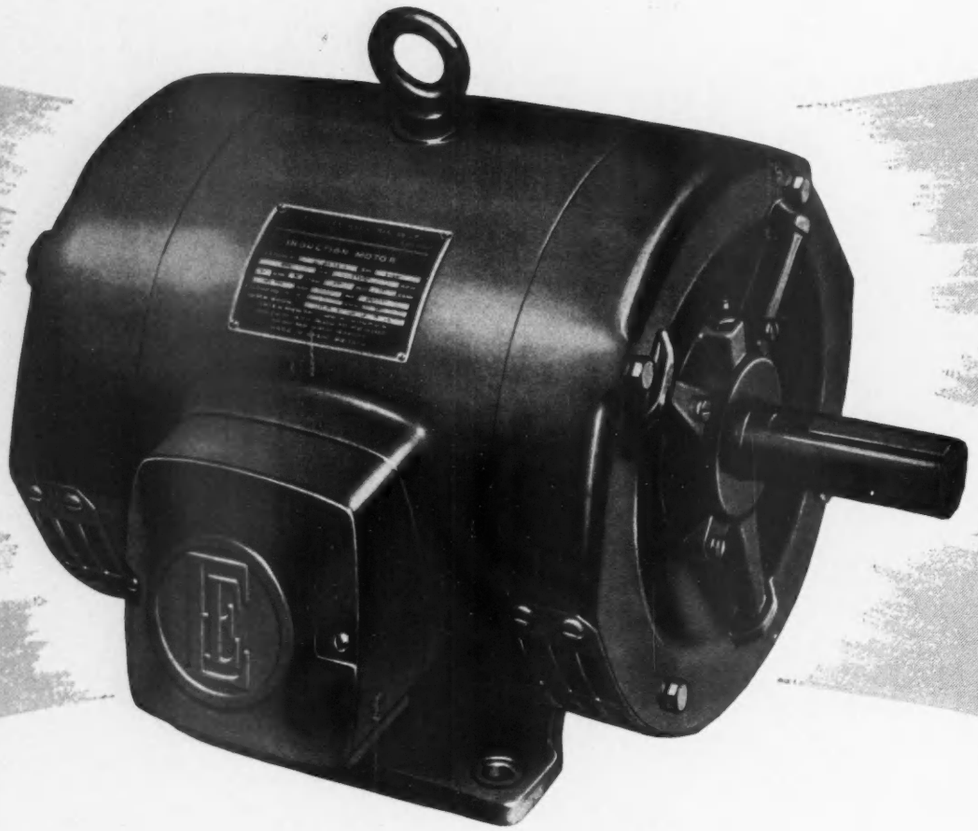

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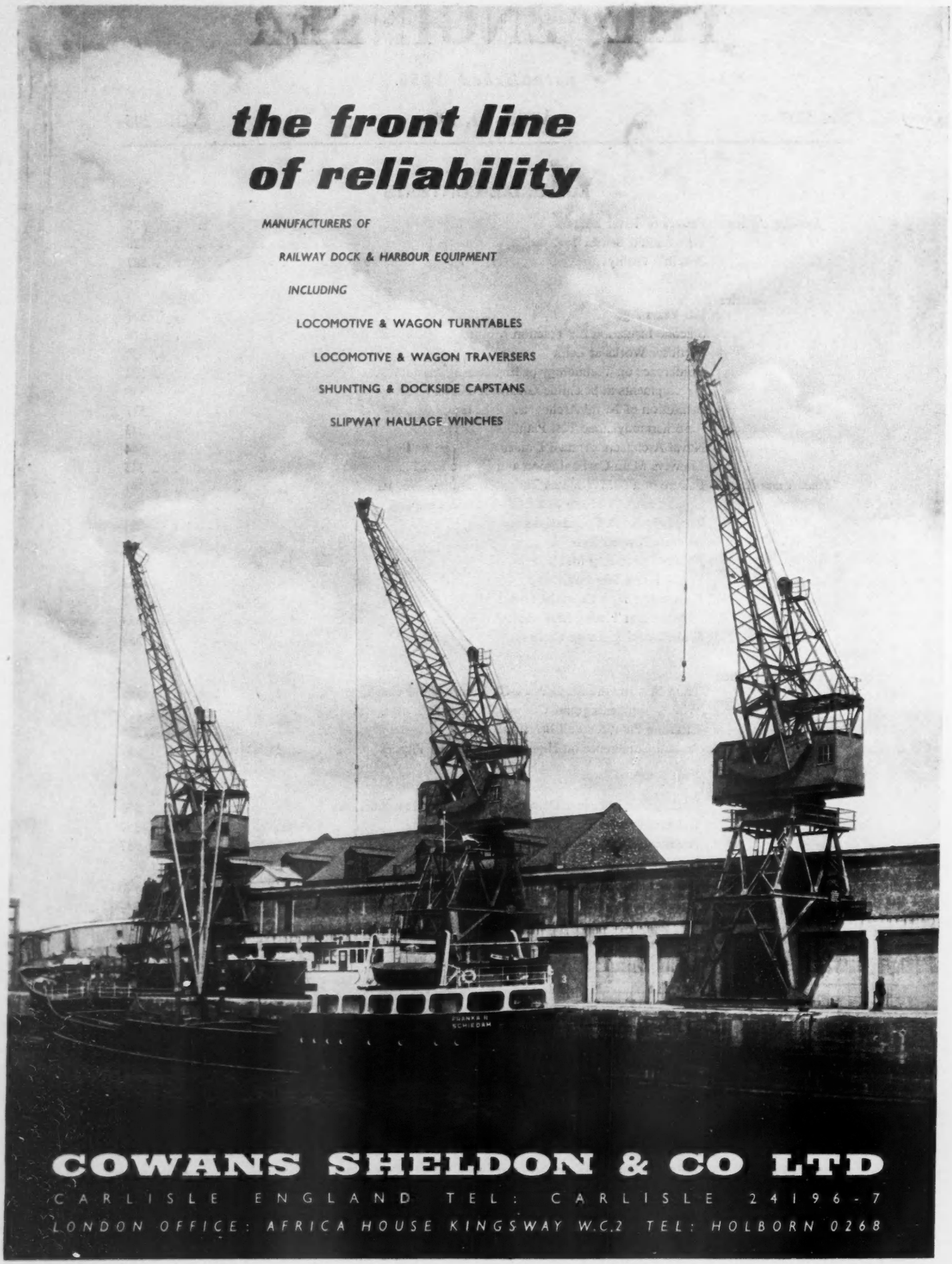

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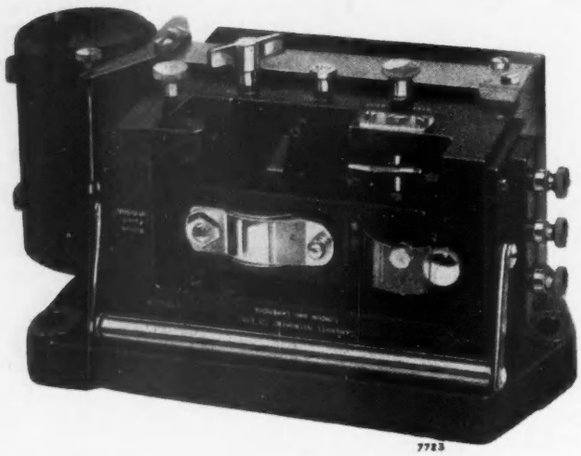

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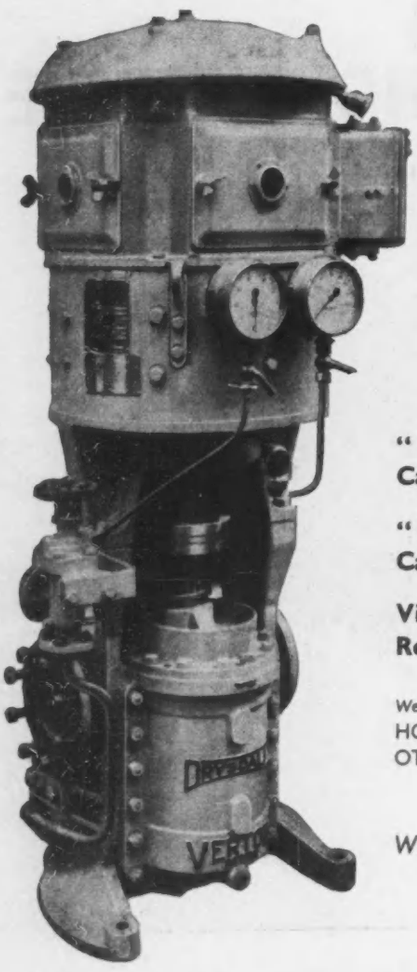

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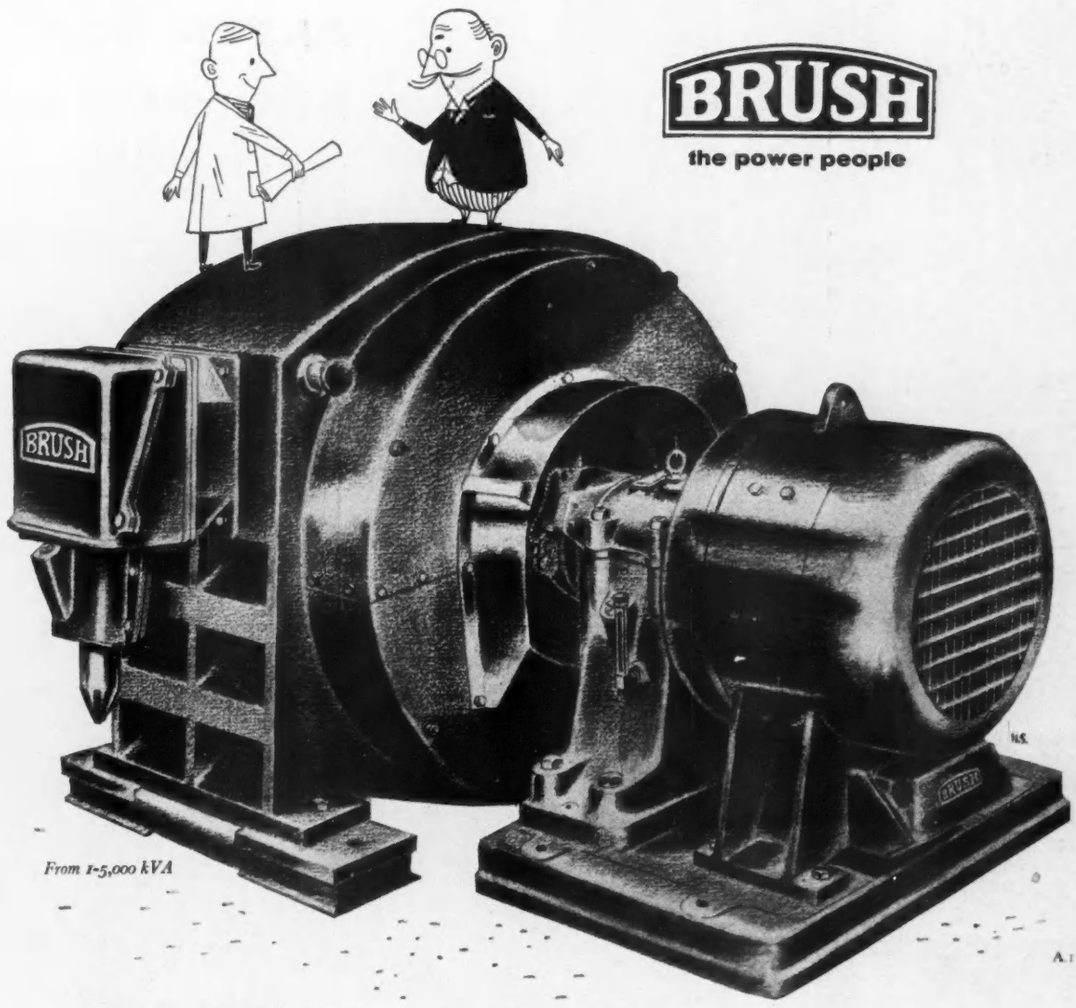

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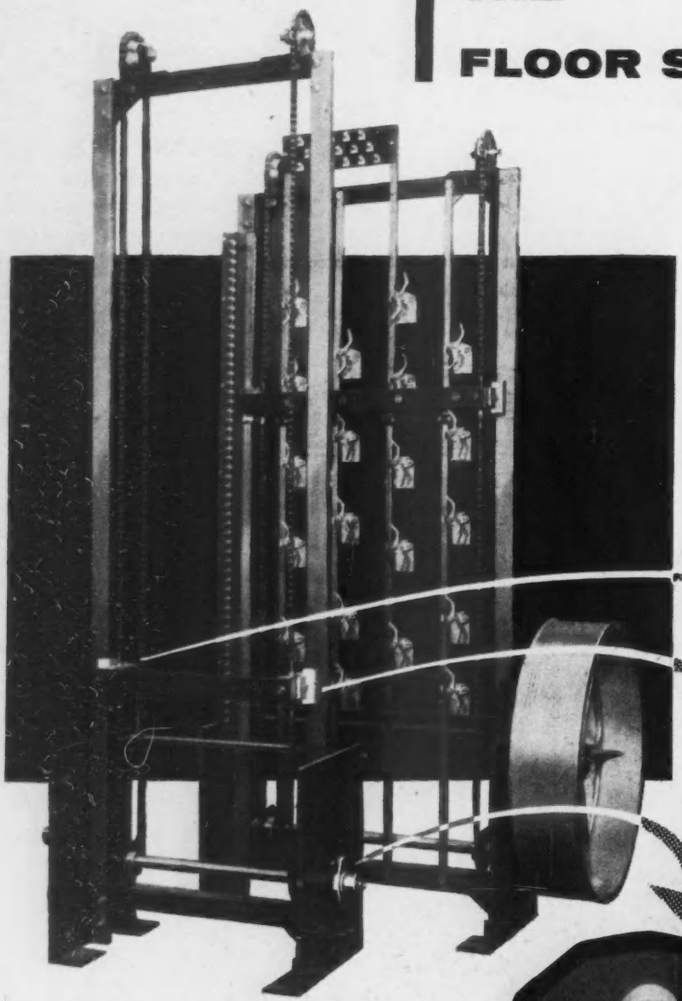

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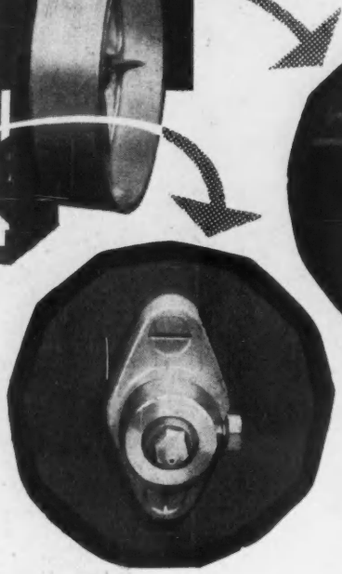

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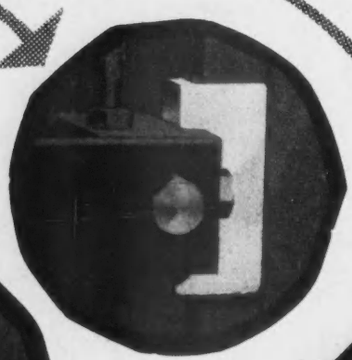
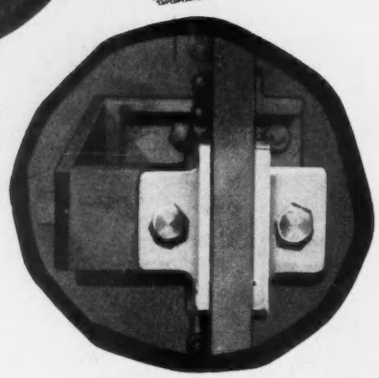


Slide bearing front view



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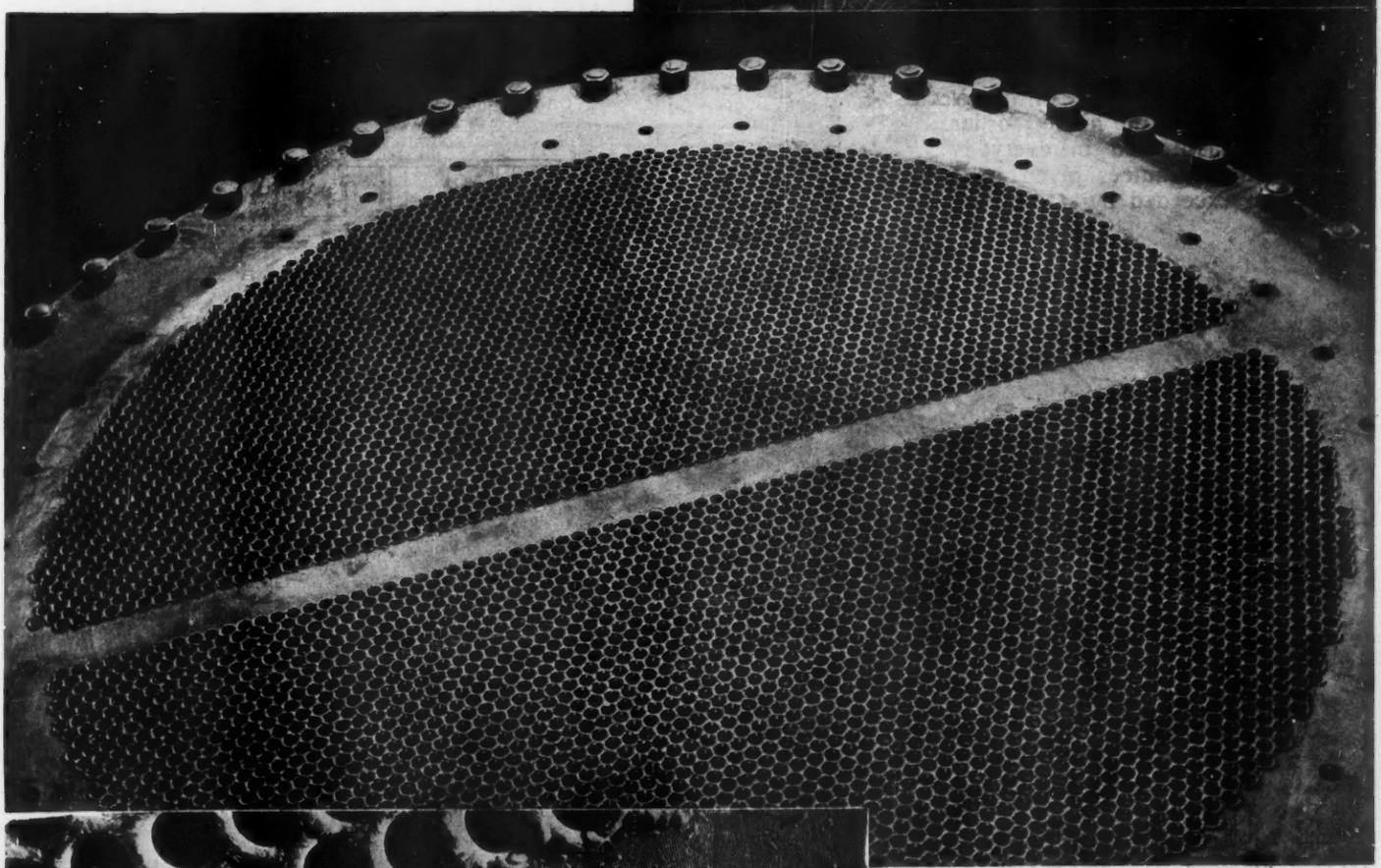

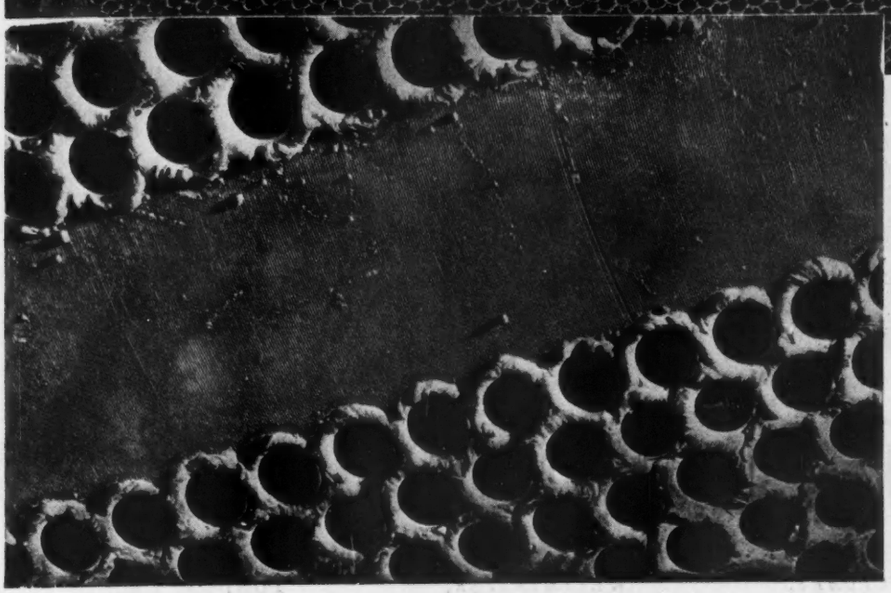

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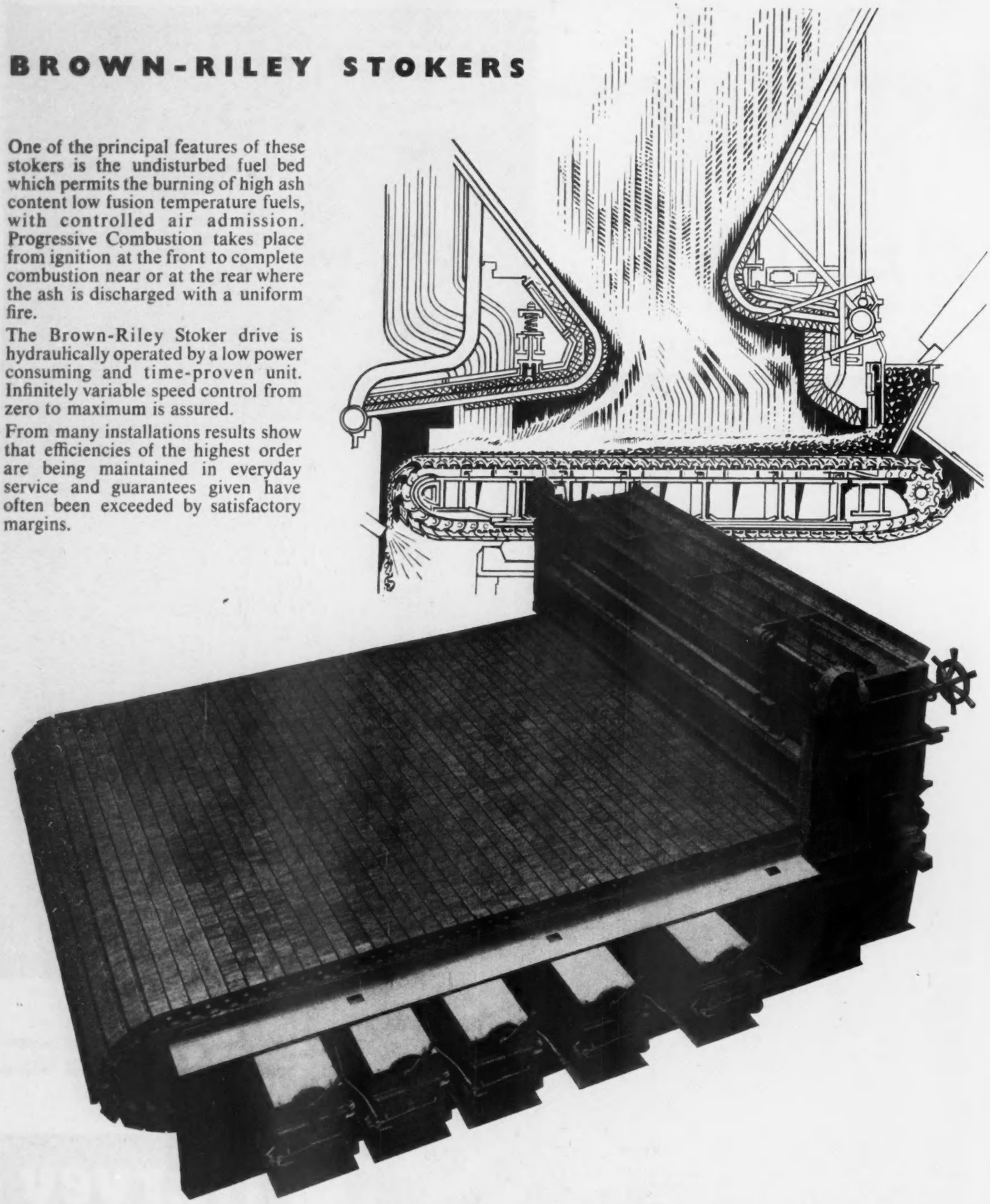

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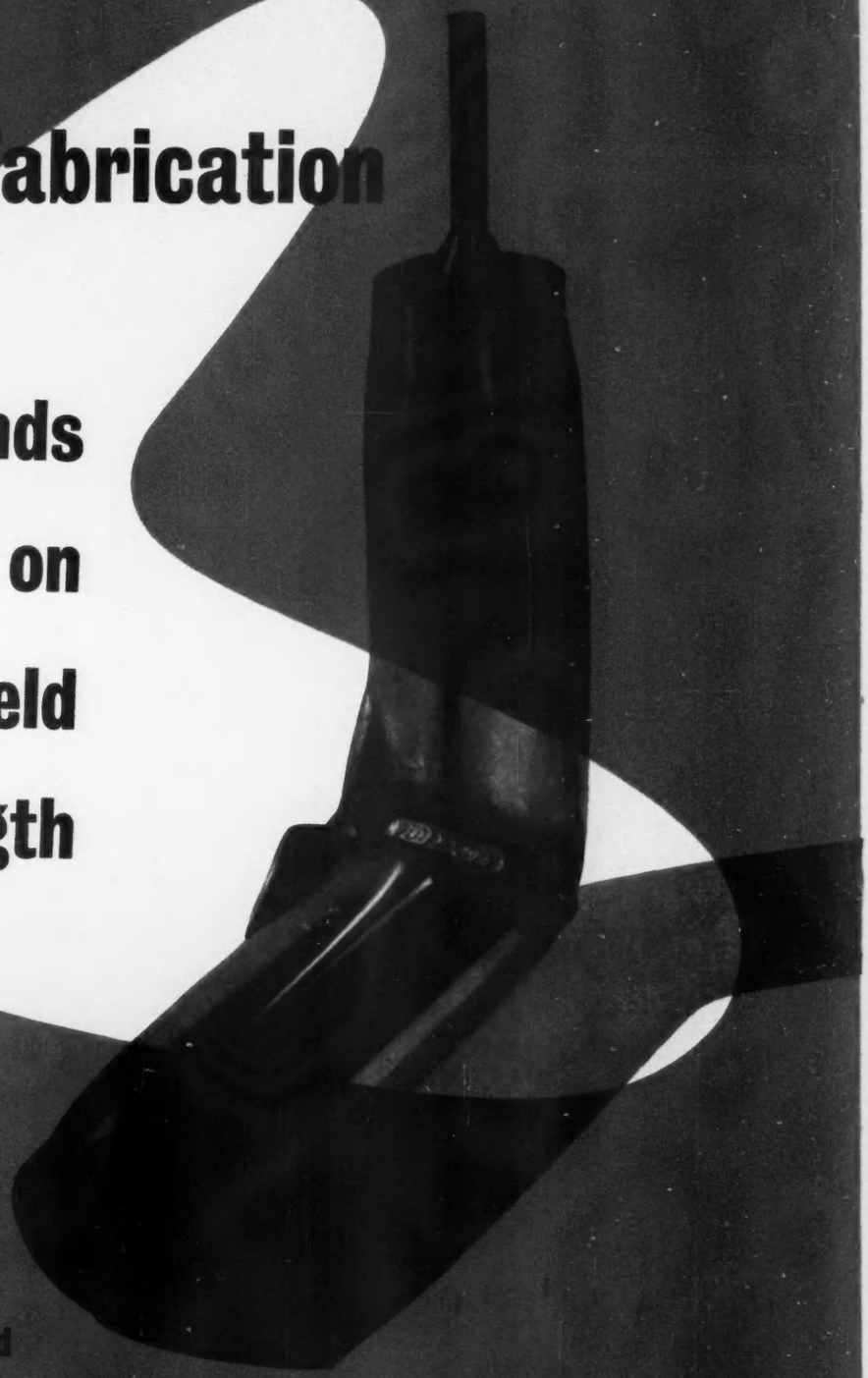

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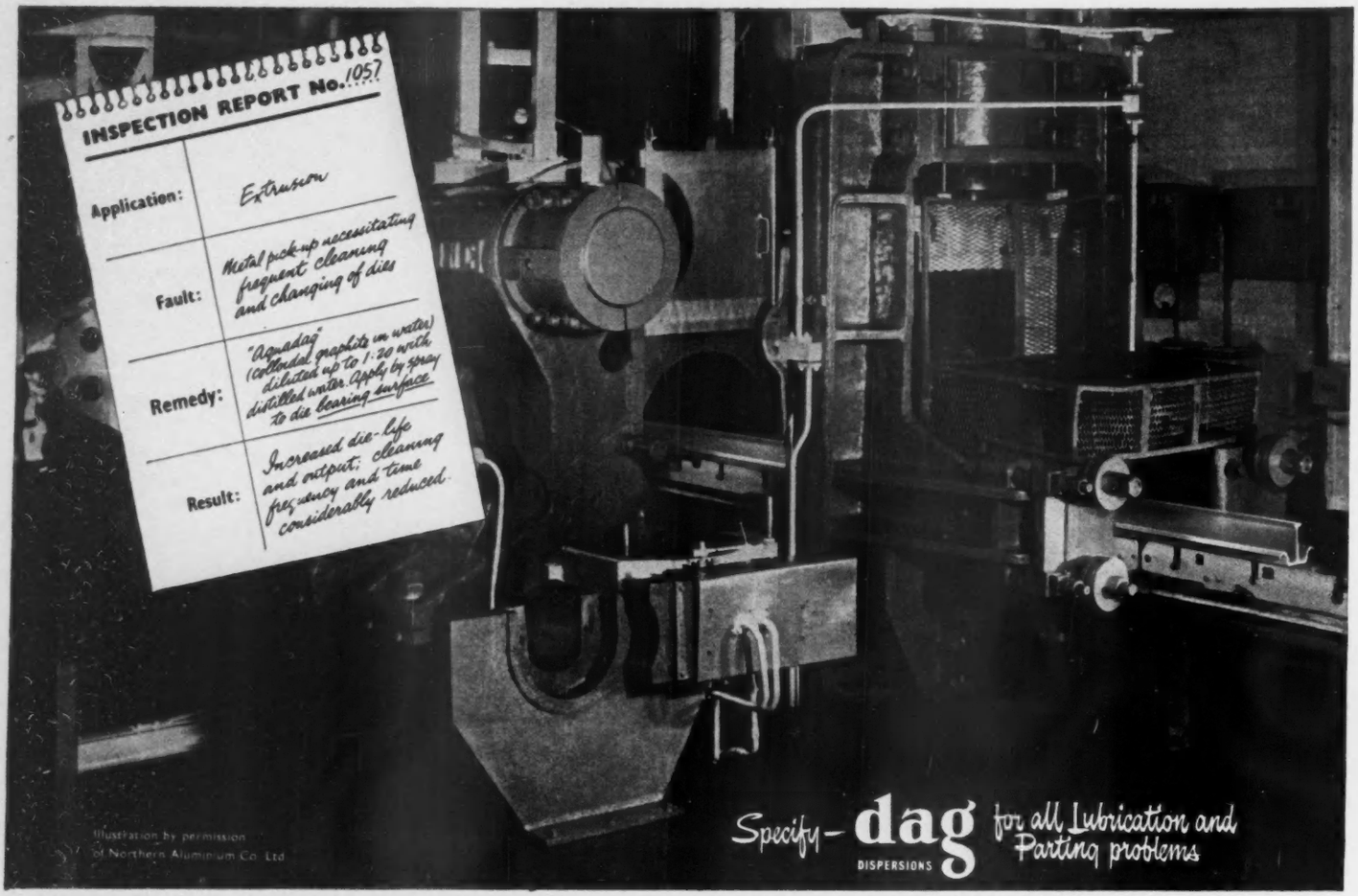
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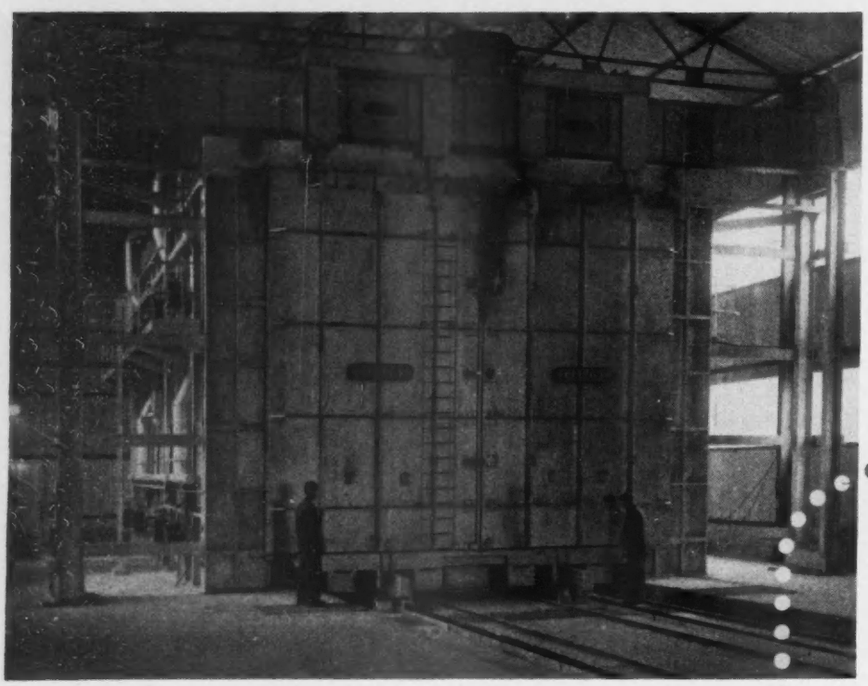

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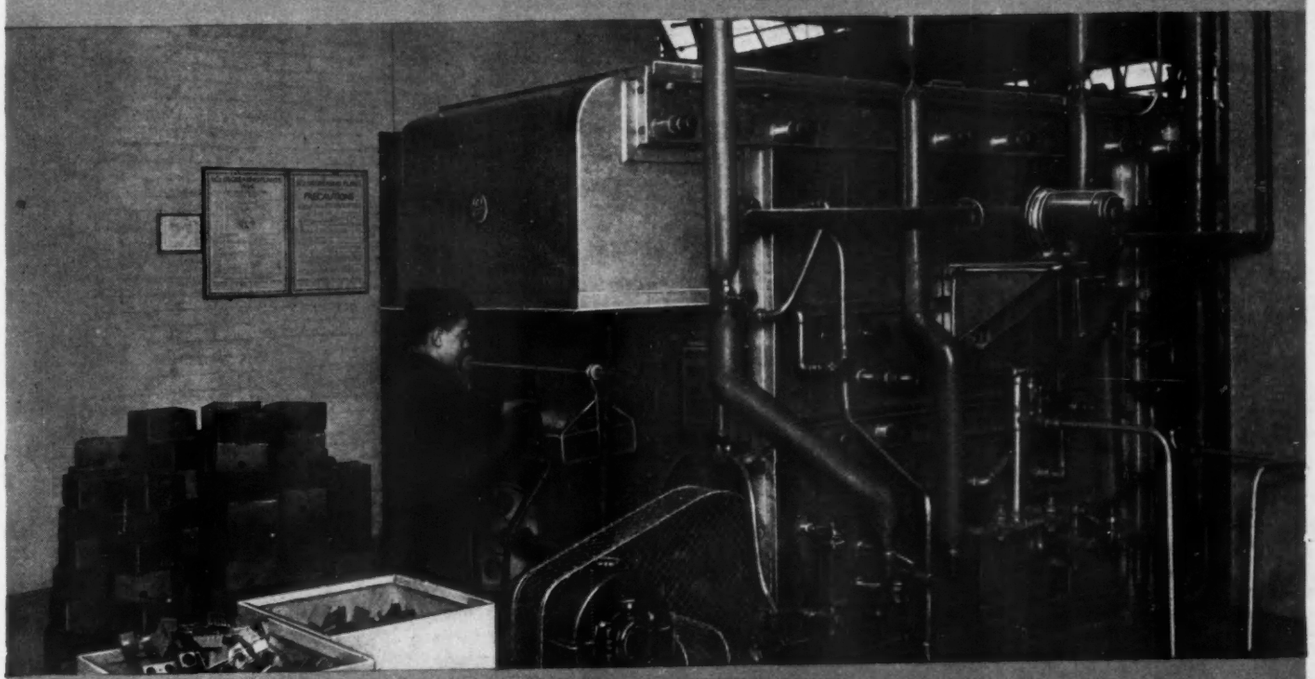

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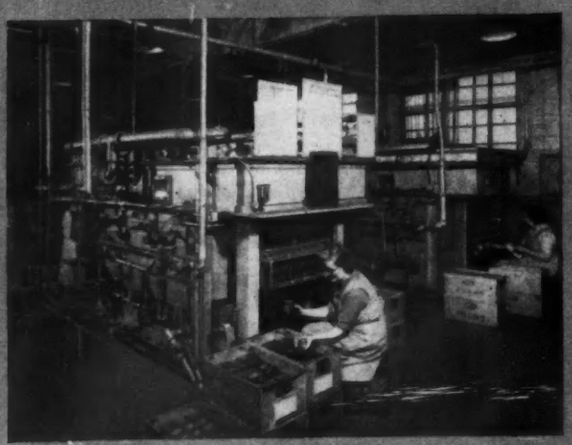

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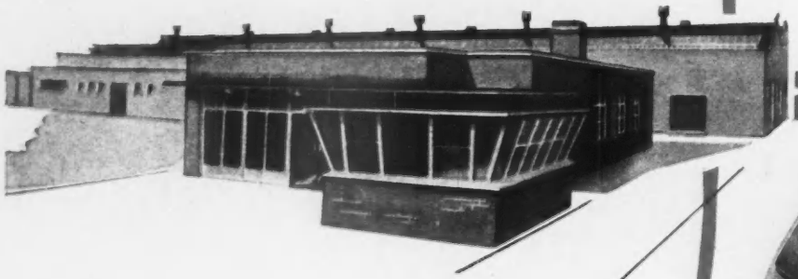

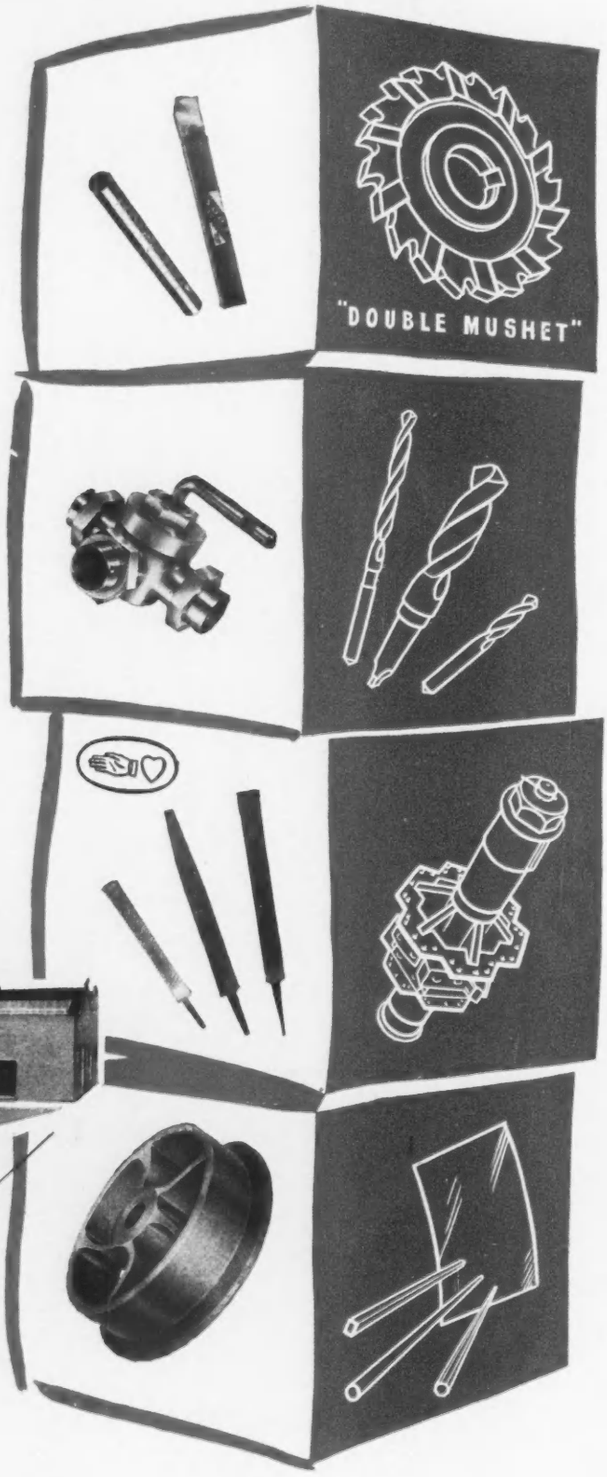

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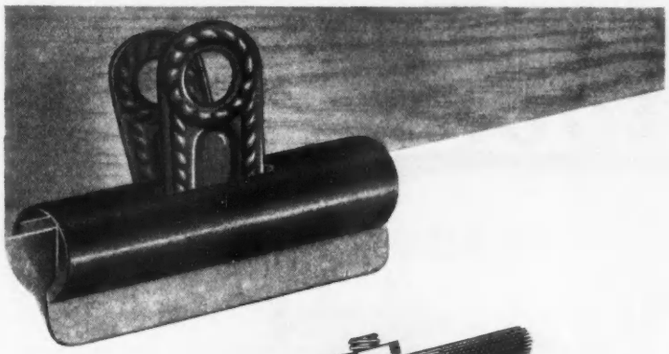

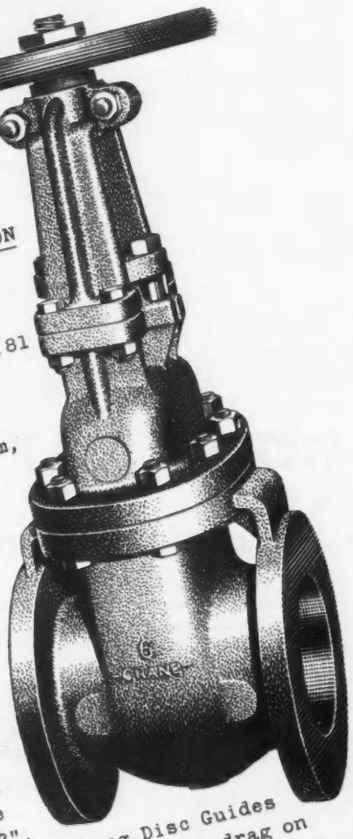

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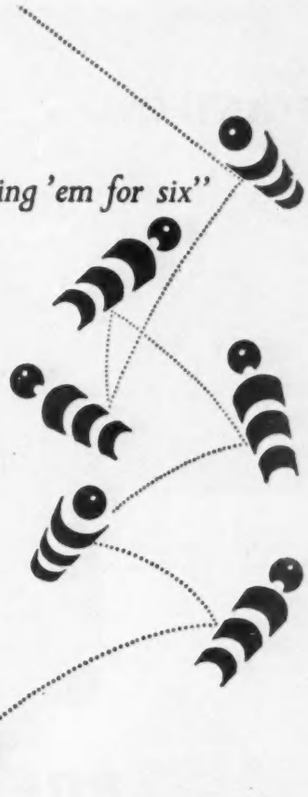

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NECO geared motors cover the whole range of speeds, types, and voltages, three phase, single phase, and D.C. up to 2 H.P. and 1500 pounds/feet torque output. Not so much a range of motors as a range of electrical drives which, within their horsepower limits, can be adapted to run at any speed, to drive any kind of machine, with foot or flange mountings to suit individual requirements.

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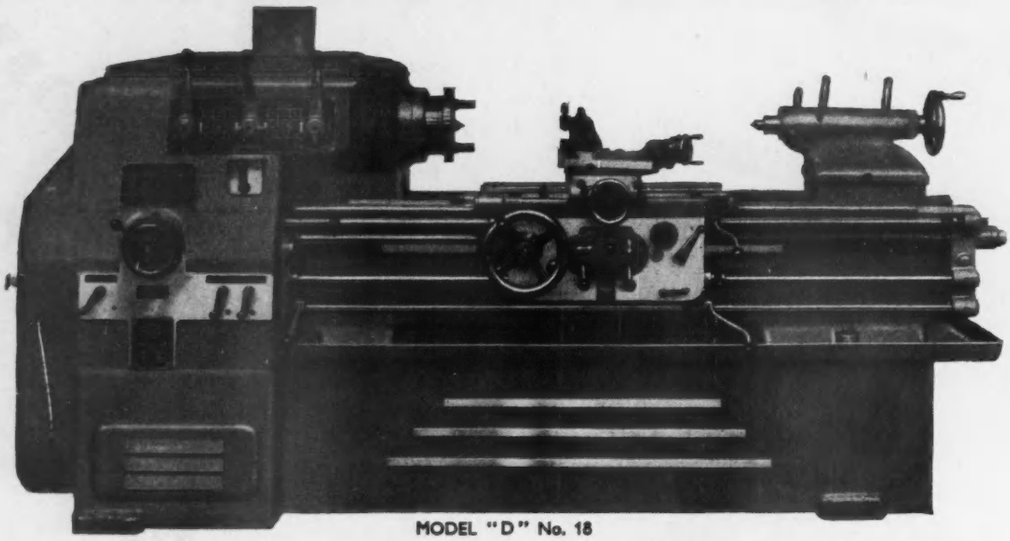

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PRECISION TOOL-ROOM LATHES

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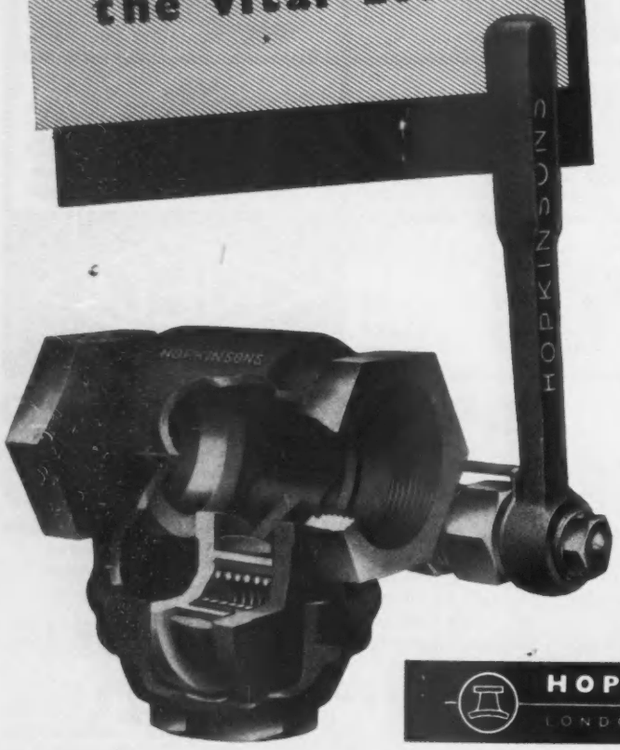
HOPKINSONS' the vital LINK



LINK valves by HOPKINSONS

There's no doubt about it—HOPKINSONS' bronze Link Valves are a vital link in all manner of industries. They handle heavy liquids such as oil and soap lines without loss of fluid-tightness or ease of operation. Having no easily-damaged external fittings, they are excellent on flexible compressed-air lines. They give long trouble-free service when handling process steam and all non-corrosive liquids. Whatever the industry there is a need for the HOPKINSON Link Valve.

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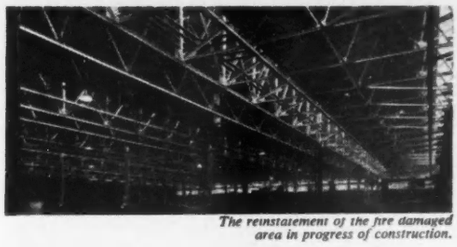
Boulton & Paul Service and Jaguar recovery

View of part of the Works after the fire.

New building erected in 9 weeks.



The reinstatement of the fire damaged area in progress of construction.

The disastrous fire that crippled the Coventry Works of Jaguar Cars, Ltd., on February 12th last year destroyed many parts of the factory and a large number of cars. Production was seriously interrupted. Early fulfilment of mounting export orders depended on the immediate clearance of debris, temporary repair of fire damaged structures and the provision of new buildings in the shortest possible time.

Boulton and Paul were privileged to play a prominent part in achieving this difficult task.

While usable parts of the fire area were being shored up, the steelwork for the new building 420′ × 180′ and containing 240 tons of steel was designed, delivered and erected in 9 weeks from receiving instructions to proceed. This enabled the building, with many parts already occupied, to be handed over to the clients on July 2nd, in 17 weeks from the start of operations.

Meanwhile, the reinstatement of the fire damaged premises covering an area of 389′ × 400′ and requiring 800 tons of steelwork and roof covering has proceeded in stages allowing virtually uninterrupted production since the fire.

A further example of the careful planning, employment of advanced techniques and meticulous attention to detail behind the Boulton and Paul service.

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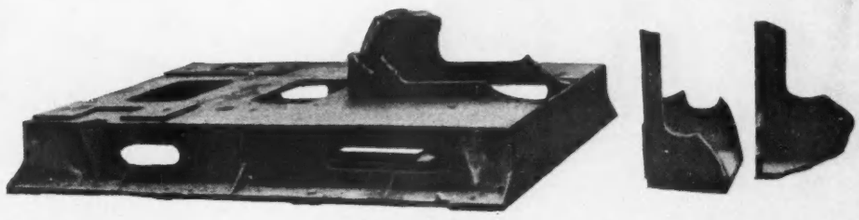
AP/CE32

BARIMAR solves a Power Problem



Badly broken cast iron bedplate from boiler house of electric power station. An indispensable piece of equipment.

The demand for electric power is taxing the capacity of generating stations.

When Authority counsels:
"Produce!—Produce!!"
Industrialists respond:
"The Juice!—The Juice!!"

DEMAND FOR POWER is climbing to such "quart-into-pint-pot" heights, that any serious breakdowns mean industrial chaos, with dislocation and "hold-ups" over wide areas. New equipment is essential if the call on electric power is to be adequately met. Meanwhile the strain is telling on hard-pressed machinery. Breakdowns follow, with small prospect of new equipment in the immediate future. What then? The logical course is to keep the power stations going with existing plant. How can this be done? Barimar Scientific Welding is the immediate answer!

IN ANY EMERGENCY
Remember—BARIMAR
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Barimar repairs are not a temporary "patching-up" of tired and broken machinery. Barimar Scientific Welding is permanent, saves time, expense and industrial interruption. And moreover, strengthens as well as repairs broken equipment. This fracture of a cast-iron bedplate in the boiler house of an Electric Power Station in Yorkshire, caused serious loss in generating capacity. The bedplate was 7ft. long and weighed two tons; the damage, as will be seen, was extensive. A *sine qua non* of this welding job was that the bedplate should be so repaired that machined faces at two different levels remained perfectly parallel. Exacting! But, as usual, this was Barimar's line of country. In brief, the finished bedplate was indistinguishable from new—fractures soundly welded, surplus metal neatly removed, and the necessary machining effected. *Repaired in fewer days than the weeks needed for replacing with new and* FULLY GUARANTEED! This promptly executed repair is typical of Barimar's contribution to Industry. Not only does Barimar Scientific Welding reduce standstills and cessation of output to a minimum, but the saving in time and on cost of replacement is in every way incalculable.

Bedplate repaired and guaranteed by Barimar. A speedy repair removed great anxiety at the Power Station.

ALL BROKEN PARTS which are transportable must be sent *CARRIAGE PAID* or delivered by customer. *Please remove all fittings and post letter advising despatch.*

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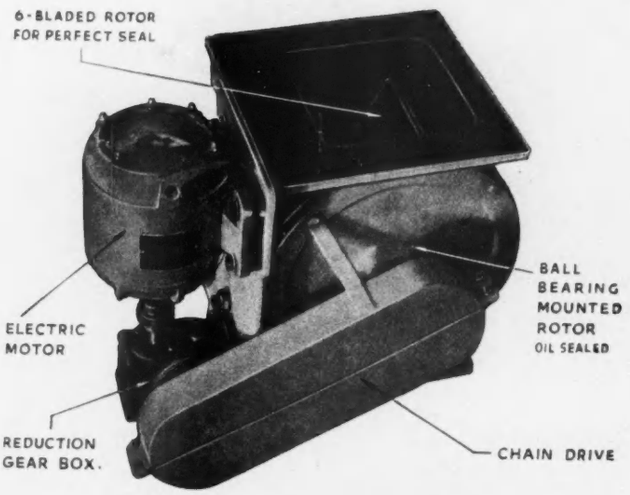

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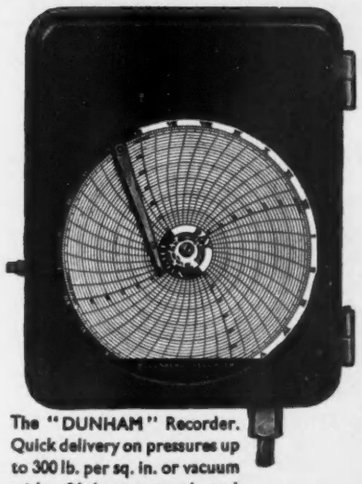

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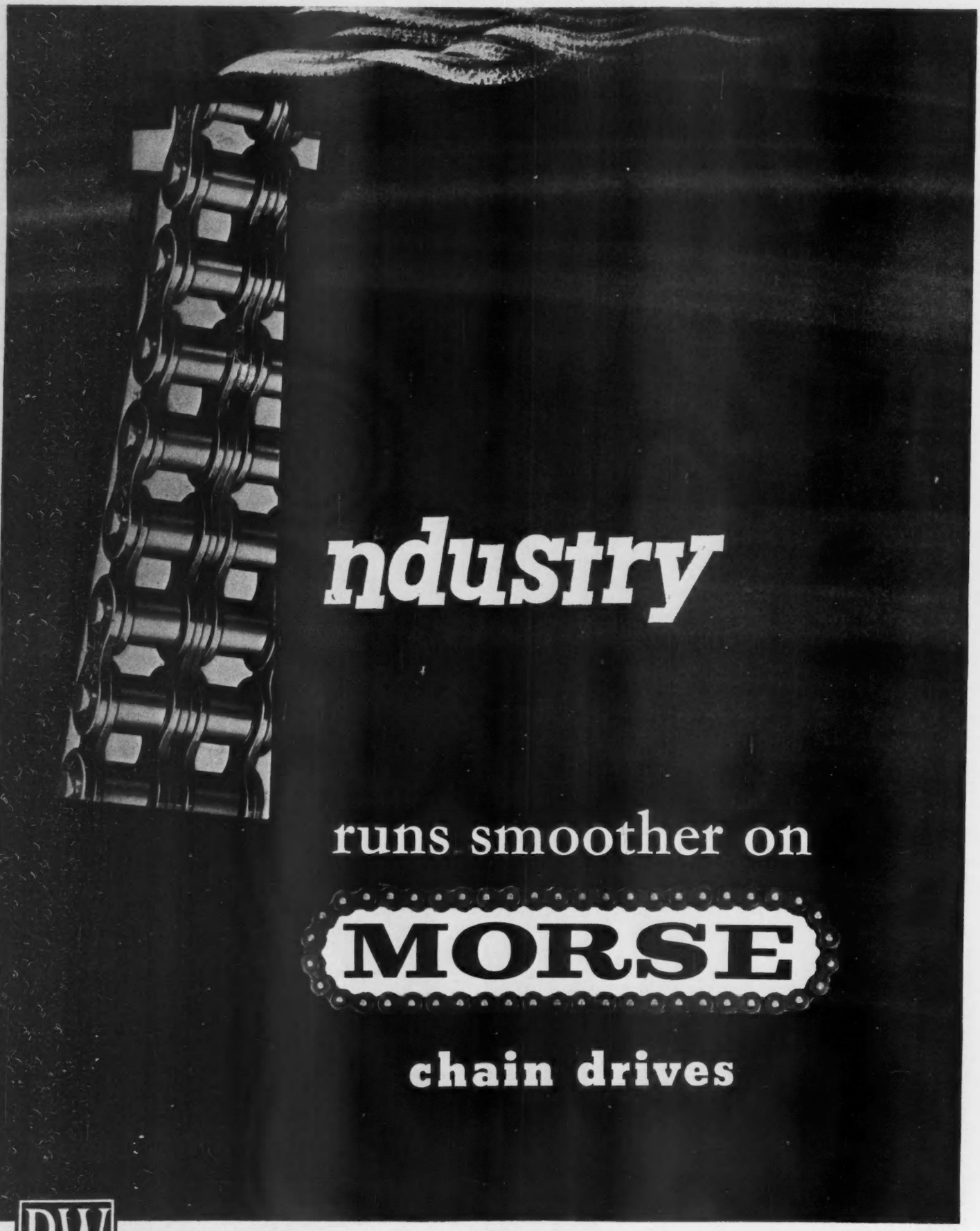

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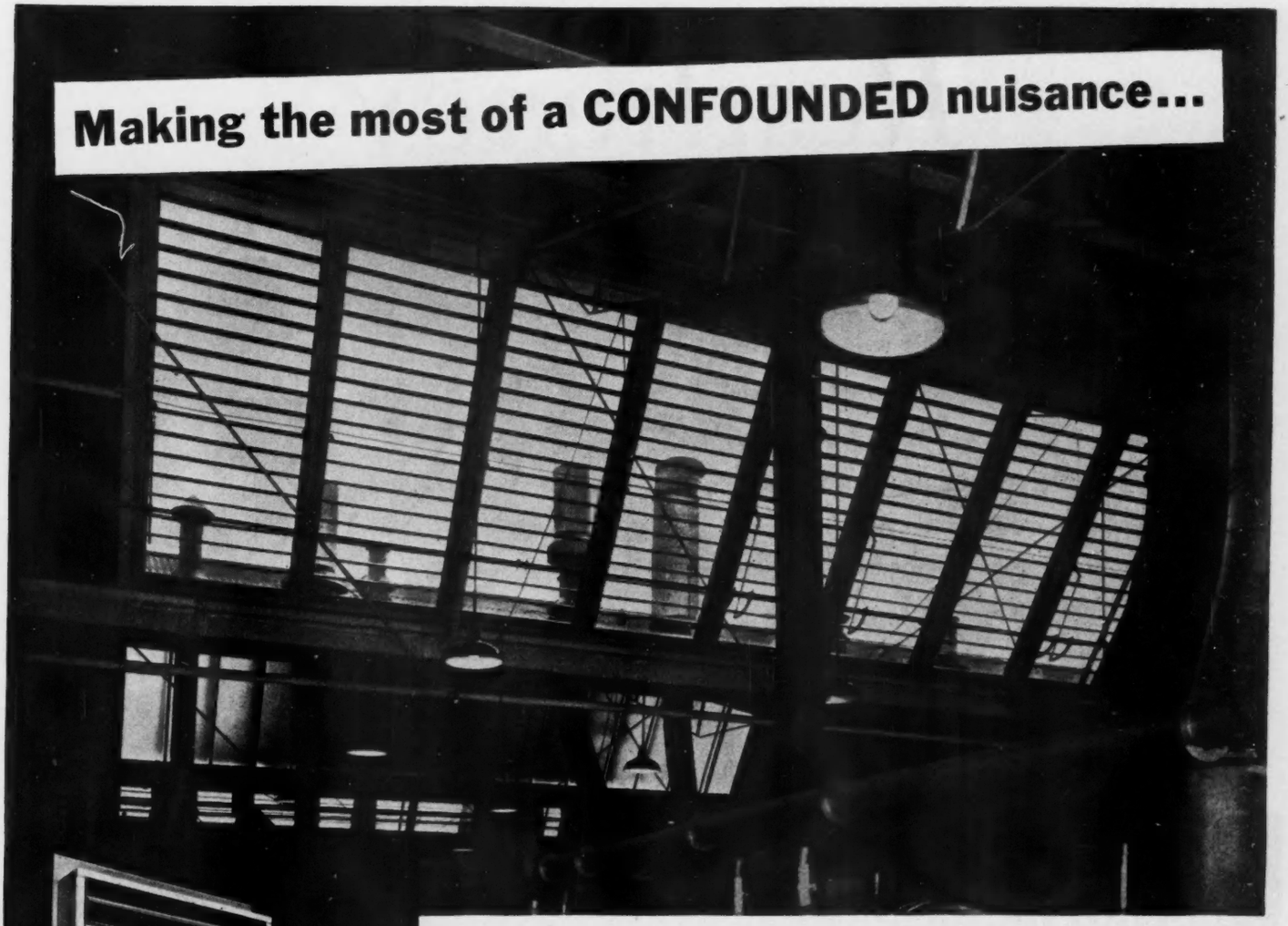

Colt CO.4080 Ventilators at Fibreglass Ltd., St. Helens, Lancashire.

Fibreglass Ltd., of St. Helens, Lancashire, were faced with the problem of process heat. Whilst planning the installation of a new glass melting tank, their engineers foresaw the possibility of overheated working conditions, and decided to solve the problem before it occurred. Already familiar with Colt Equipment, they proposed a ventilation scheme, and consulted Colt.

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Colts have learned through long experience that no two ventilation problems are the same, that each has its peculiarities, its special requirements. Our Technical and Advisory Staff are always ready to give your problem the special attention it deserves ; to adapt the practical experience of many years to your specific needs. This service, incidentally, is offered without charge or obligation.

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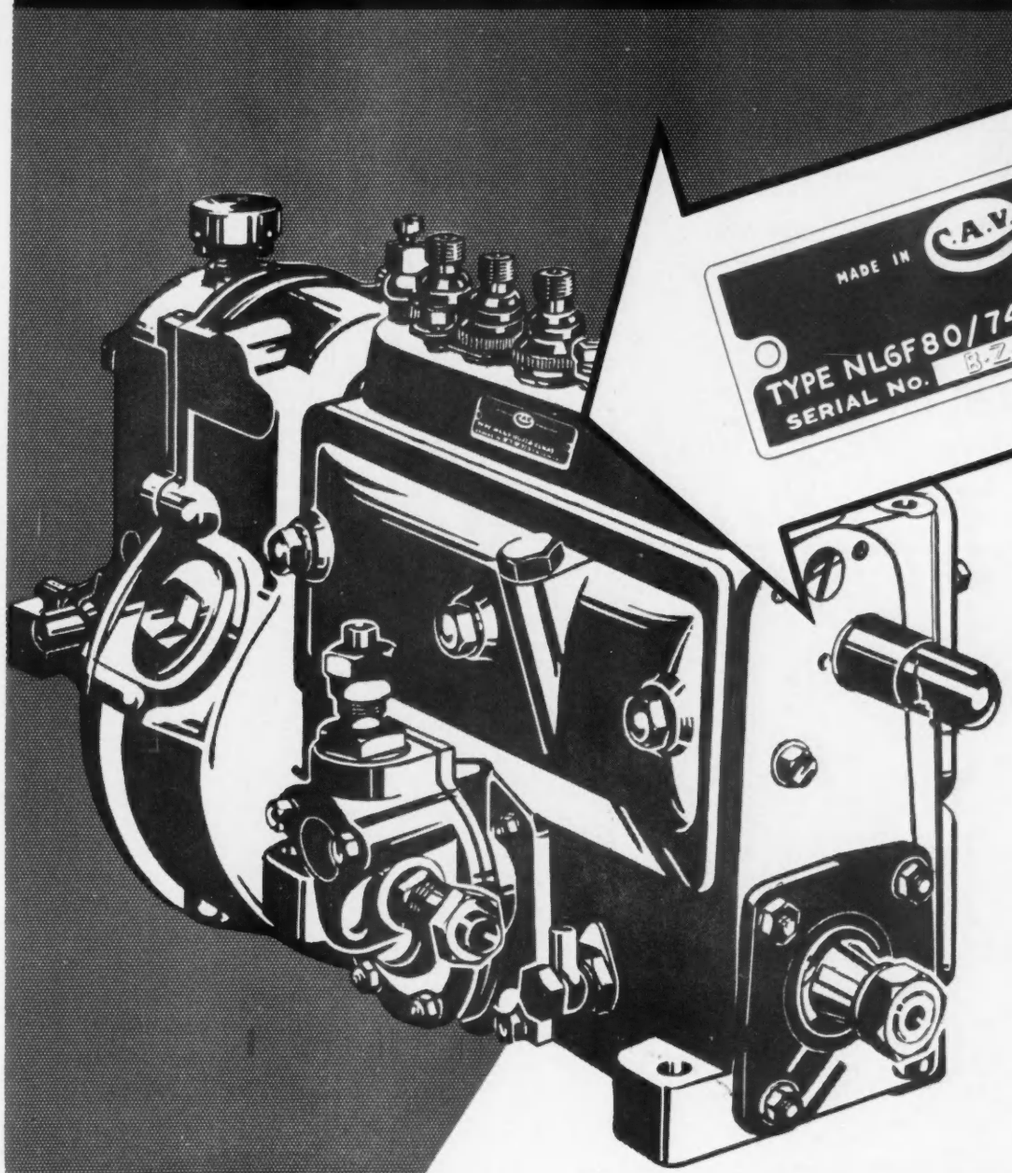

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AP 678

A long time has passed since the clarion call of Henry V rang over the battlefields of France. His sword, his armour and his shield are insubstantial shadows in the mists of history. The days of hauberk, gauntlet and lance have gone forever and the dreams for which men fought and died are forgotten.

There are still battles to be won, but not on the bloody fields of Crecy, Agincourt, or Flanders, or with the clumsy impedimenta of war. The time is the present and the struggle is for power.

This is power for industry, and at Dounreay the United Kingdom Atomic Energy Authority are developing the means to produce more and cheaper power for all. Here no less than 34 Crossley diesel engines, with a total output of more than 8,200 b.h.p., will provide power for essential duties at the station. Other nuclear power stations, like Bradwell, Berkeley, Calder Hall "A" and "B" and Chapel Cross depend on Crossley diesel engines for standby power.

To Henry all this would seem miraculous and far removed from his medieval England, yet we can adapt his words to the present. Today, wherever power for industry is needed, the breach can be filled with Crossley diesel engines, the most dependable in the world.

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UNTO THE BREACH

DEAR FRIENDS,

ONCE MORE"

CROSSLEY DIESEL ENGINES

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Explorer or football fan, you can find looking for Stanley a lengthy business if you don't know where you're going. The point comes when you have to decide whether to carry on or change to something else.

Rather like drying things by steam-heat.

In many drying processes, it is common sense to get rid of much of the water mechanically, leaving the minimum of steam-heat to finish the job.

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This is the kind of subject which we discuss in our bi-monthly publication called " Topics ". In the next issue we are, in fact, discussing the profitable points of mechanical drying. Would you like a copy of the article ?

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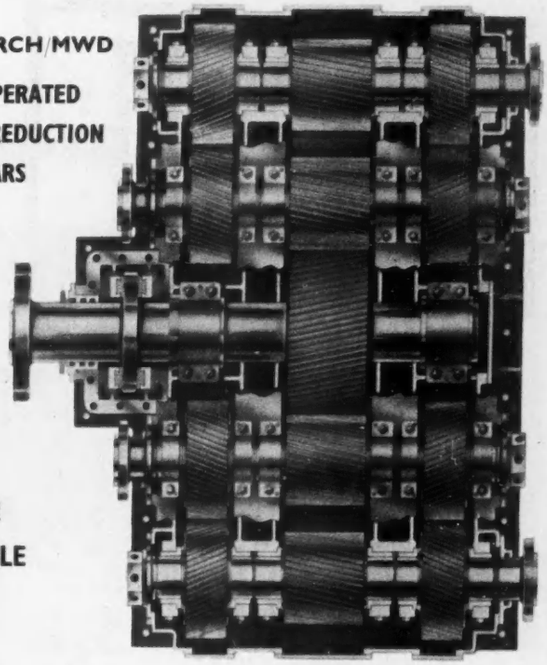

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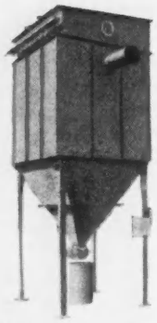

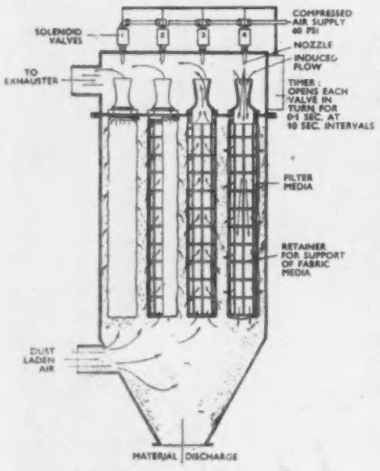

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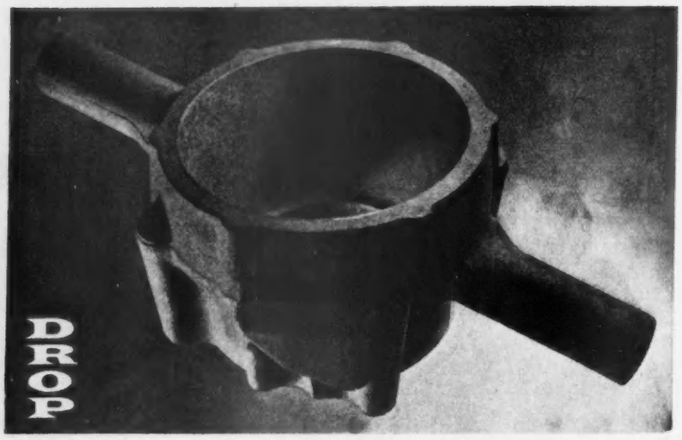

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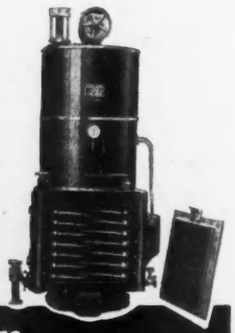

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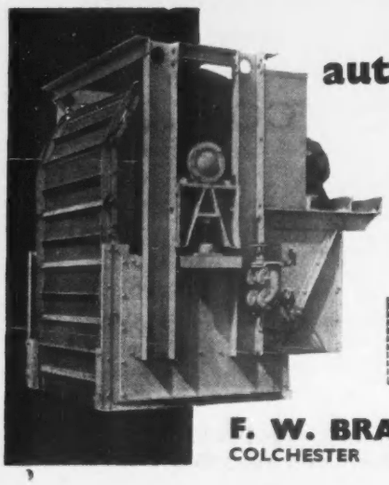

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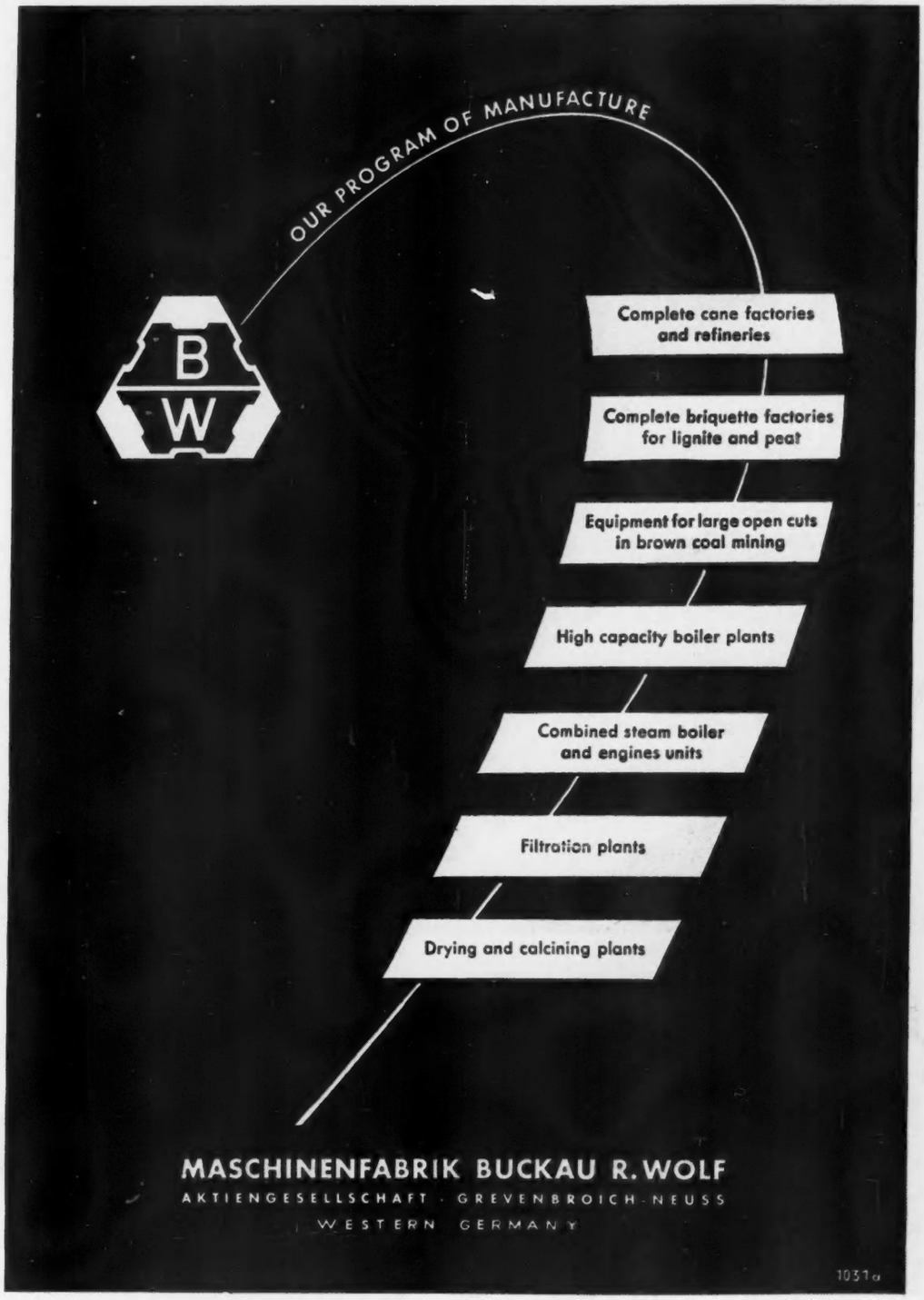
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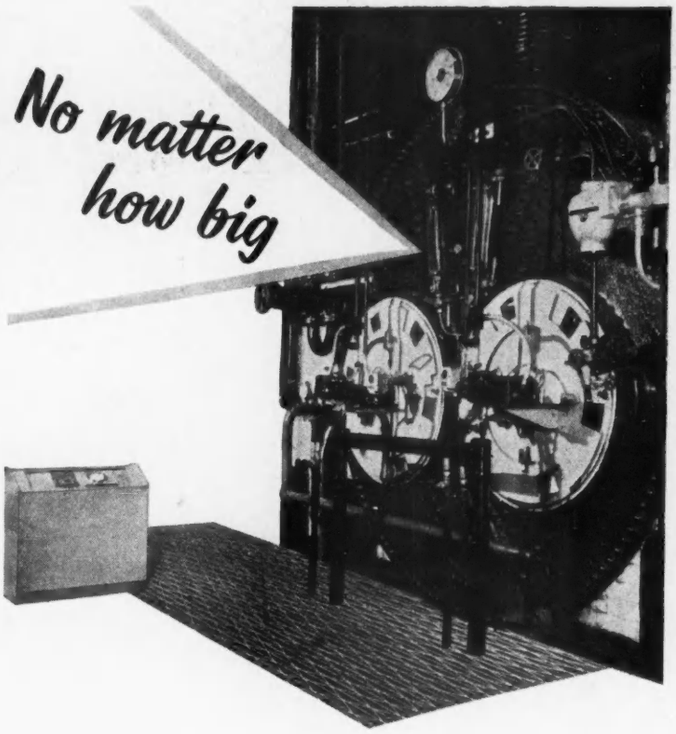

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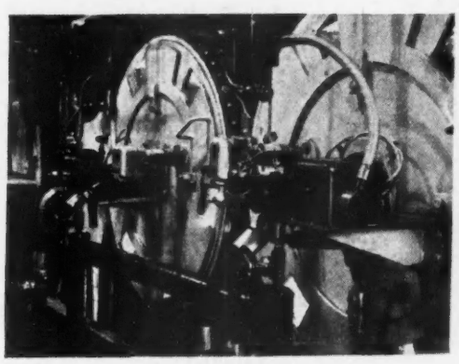

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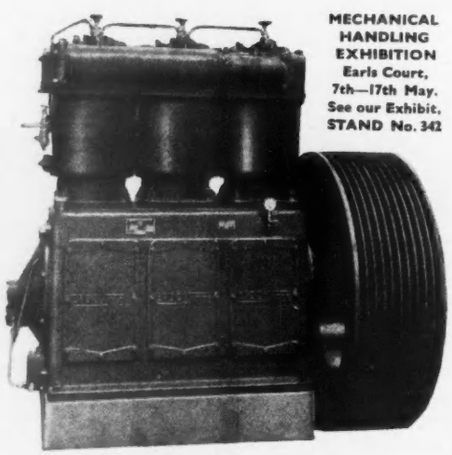

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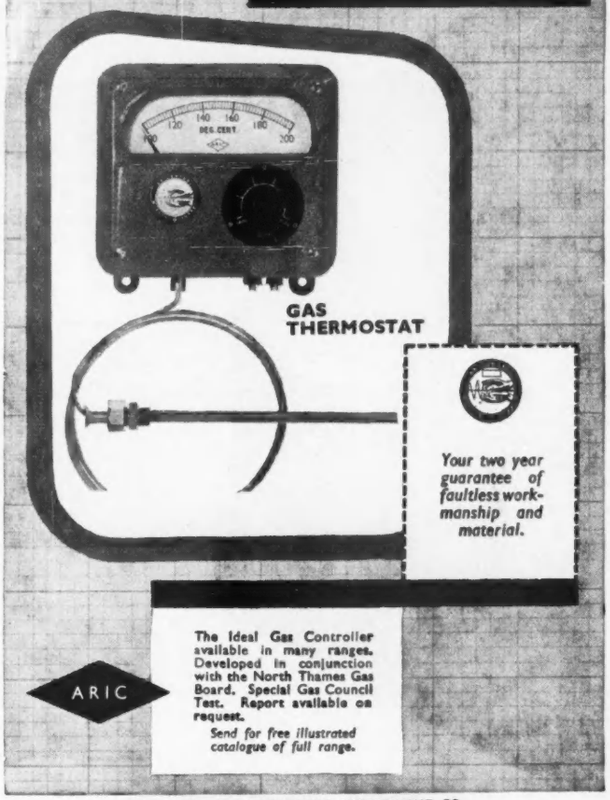
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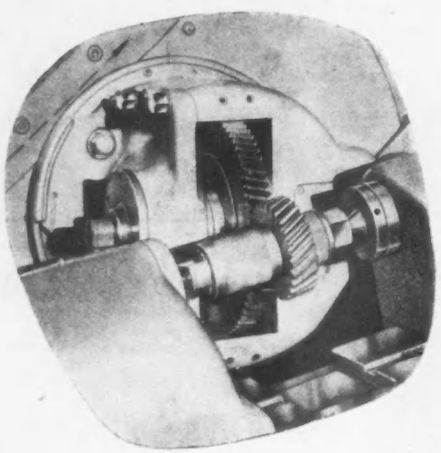

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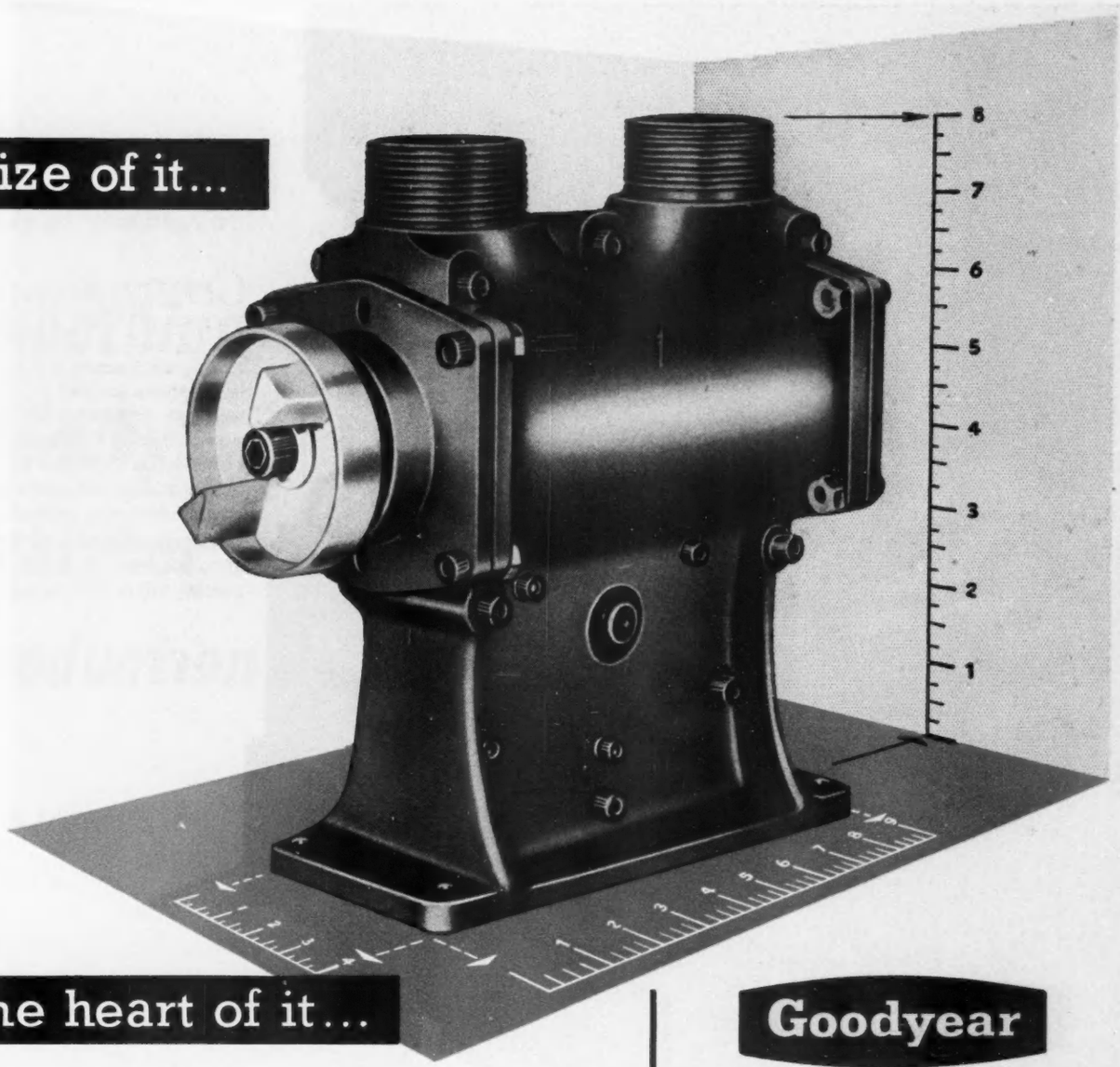

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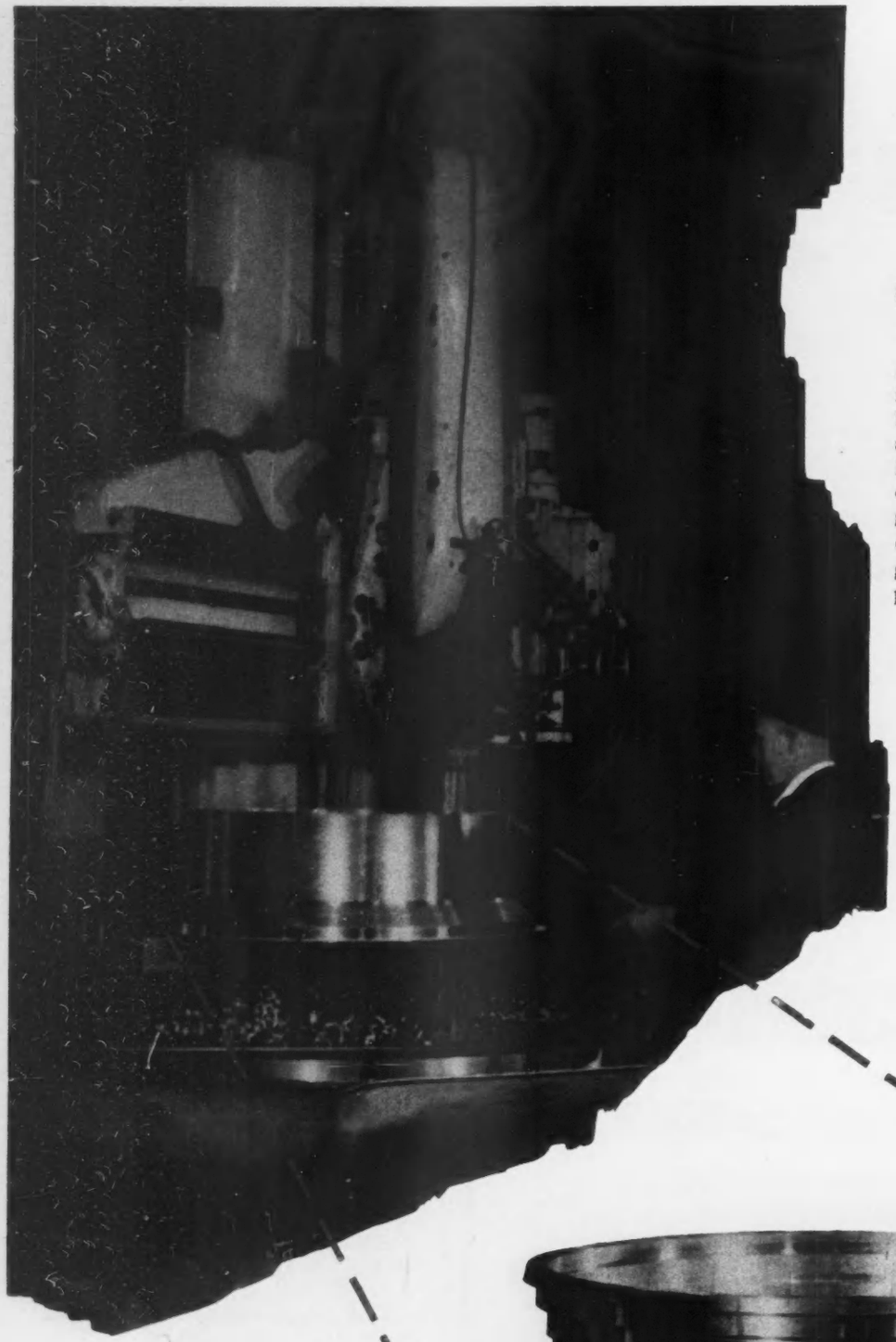

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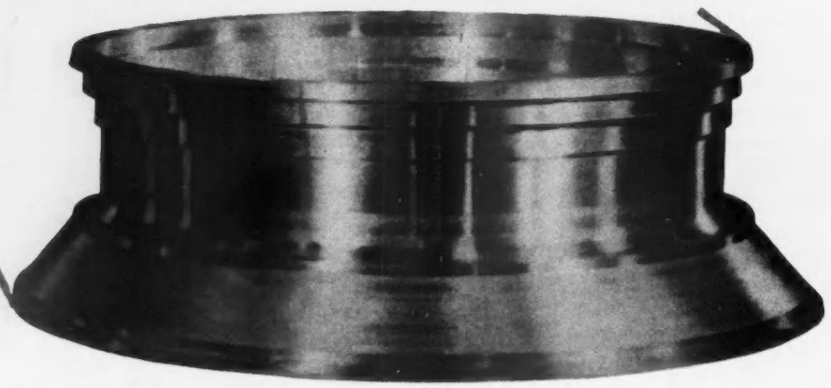

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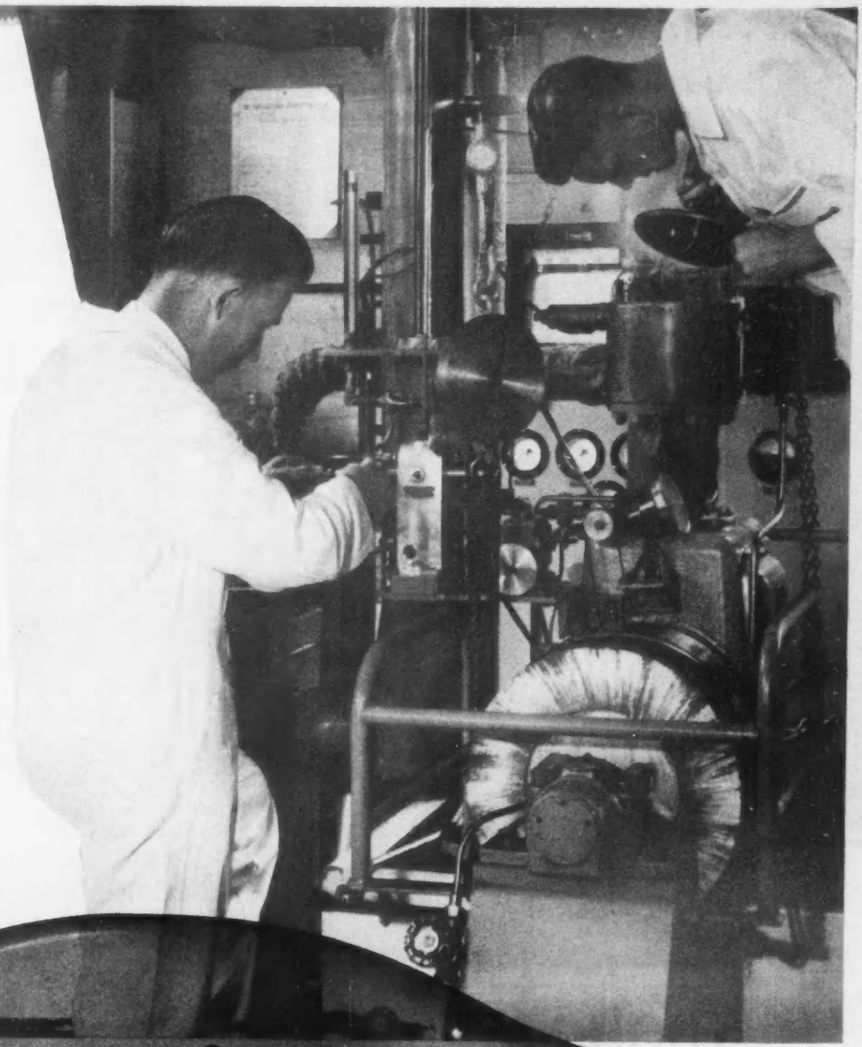

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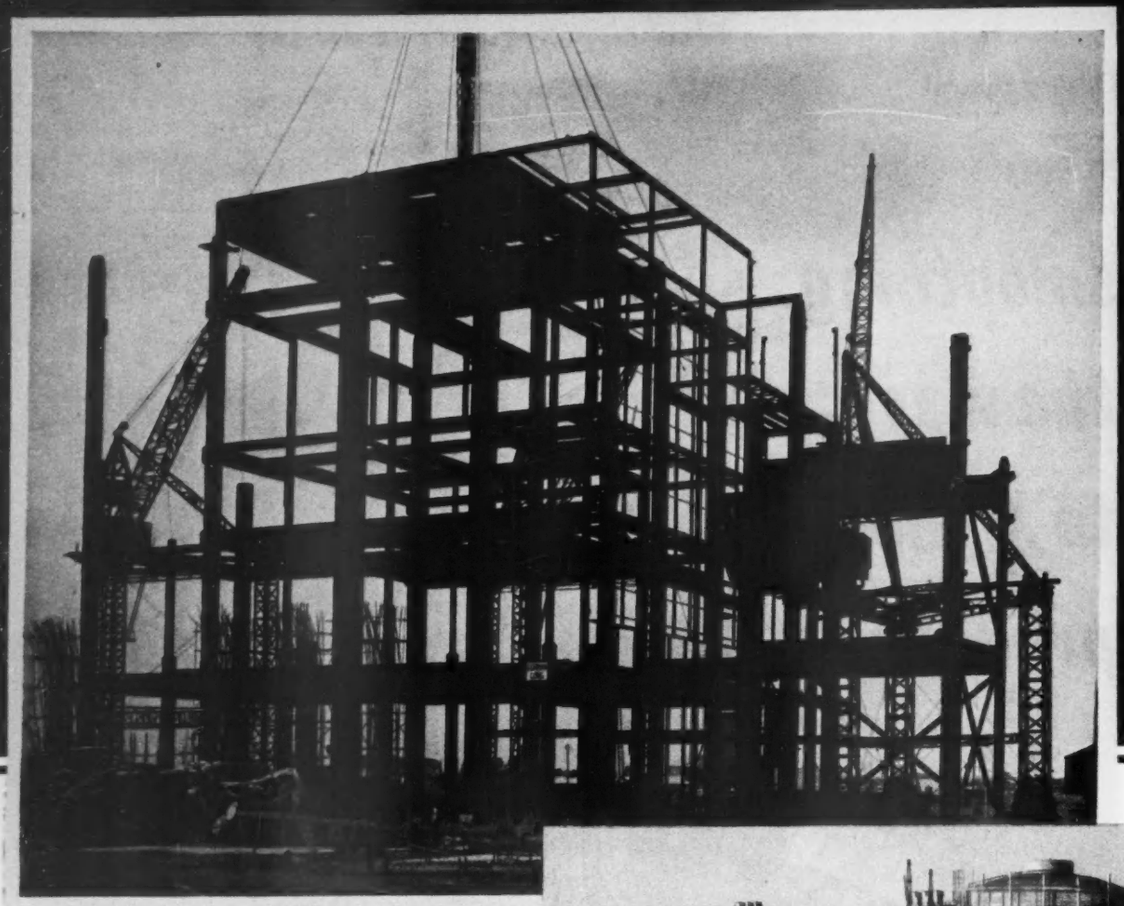

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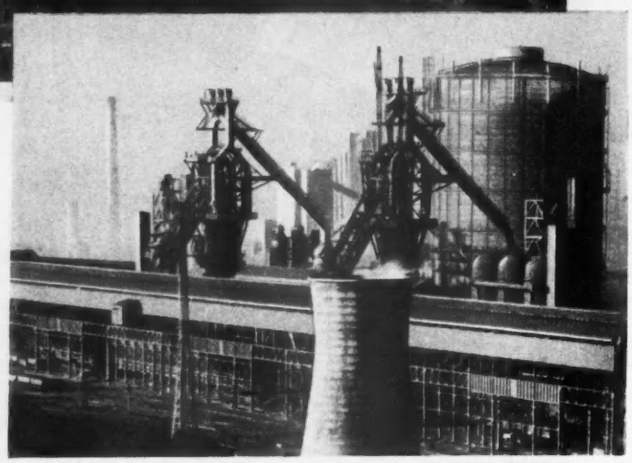

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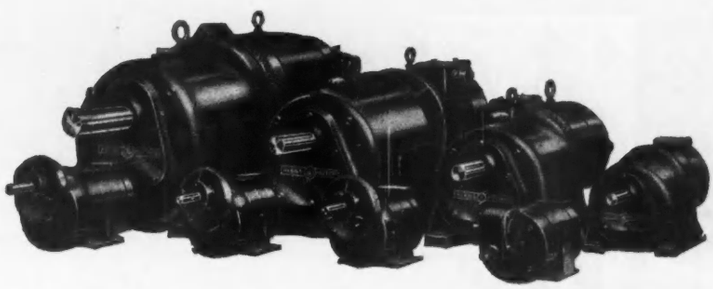

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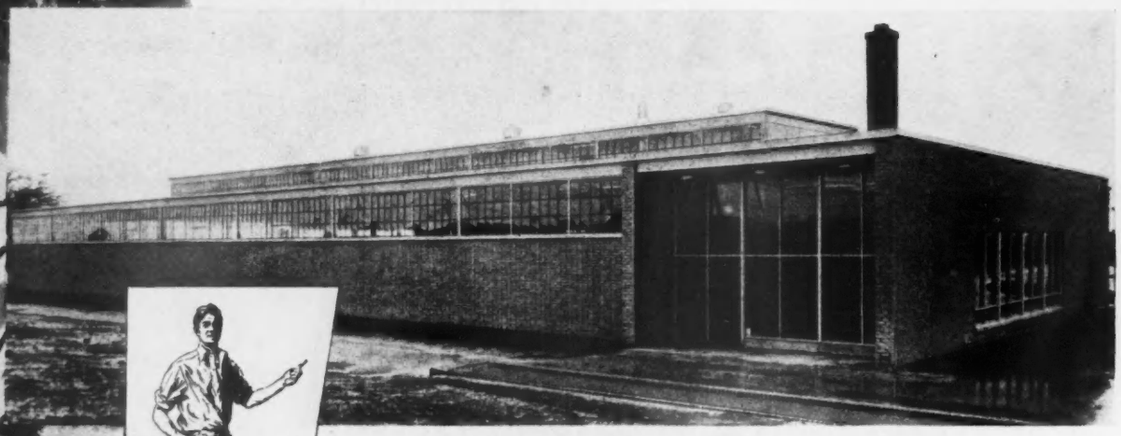

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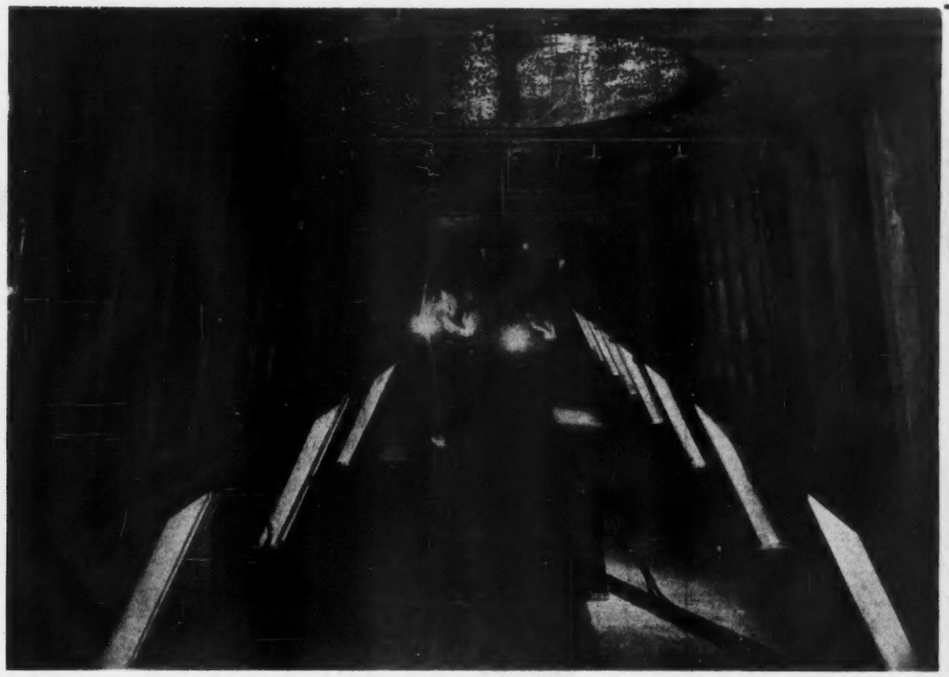

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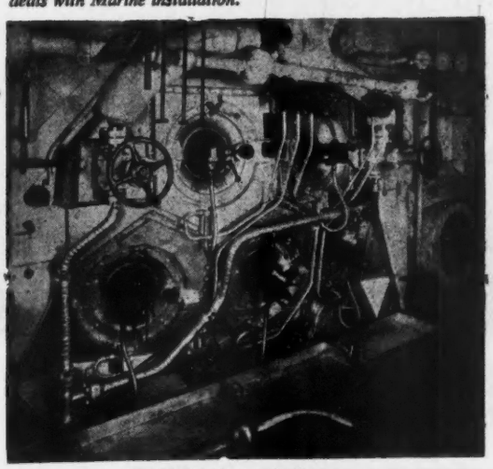

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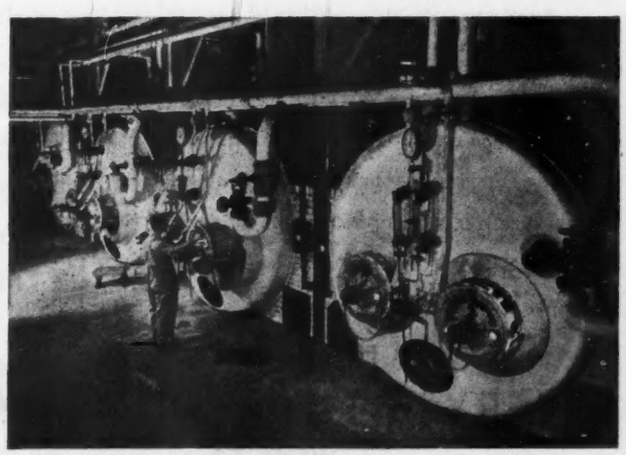

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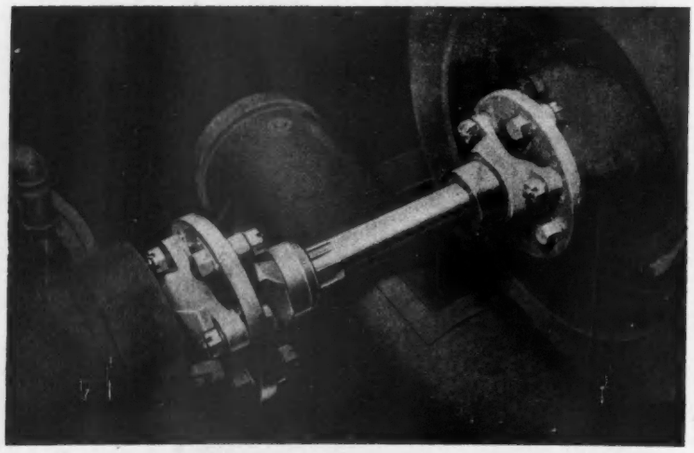

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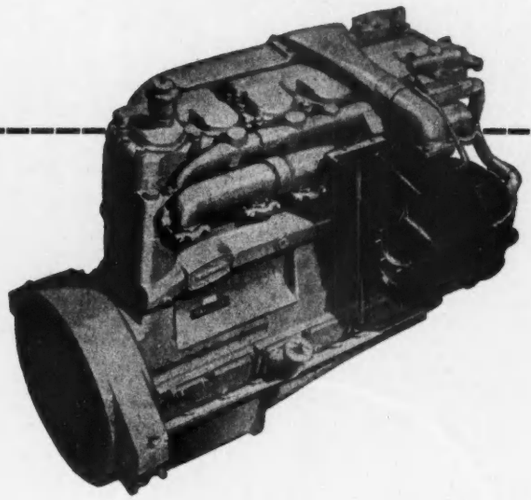

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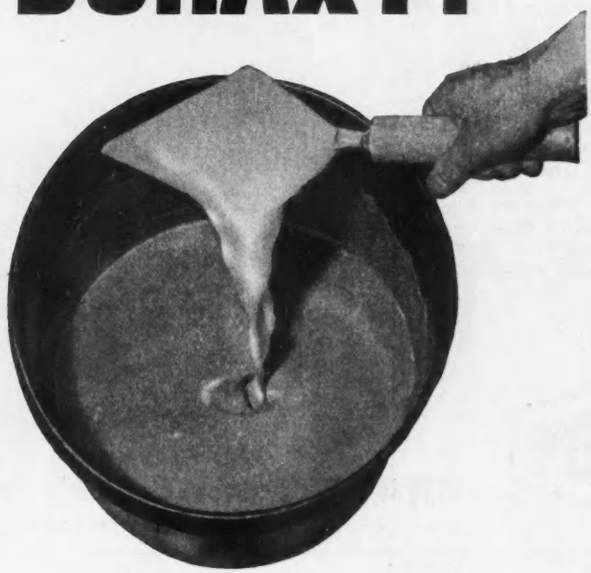

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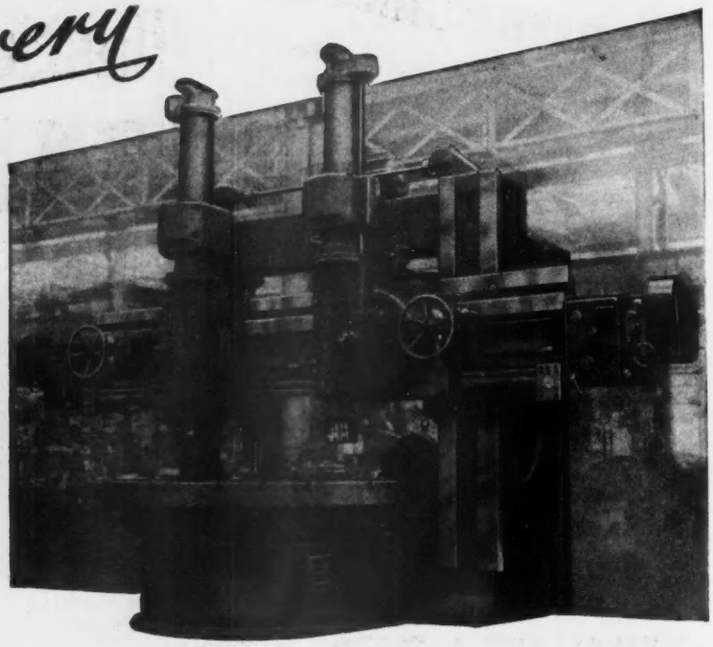

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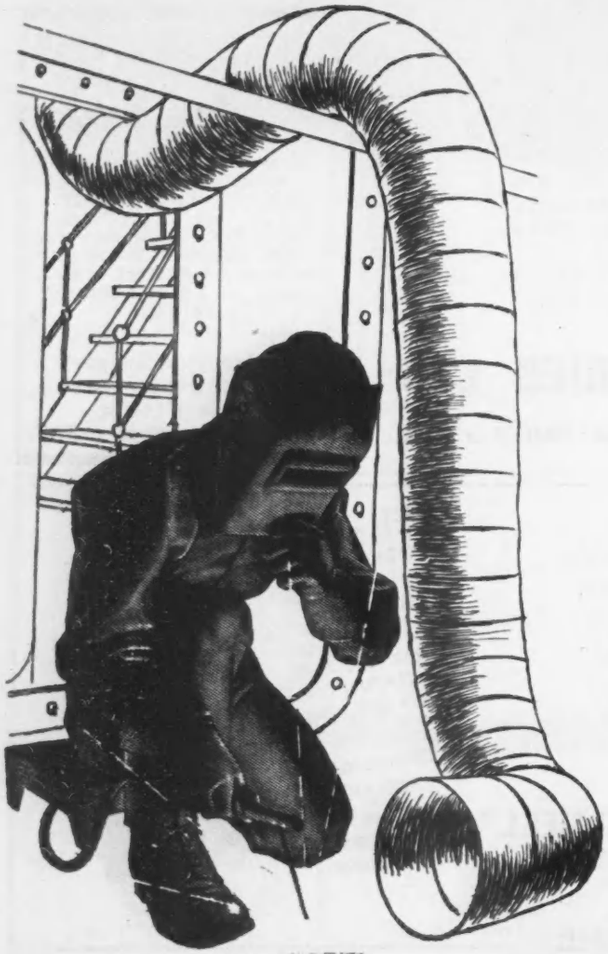

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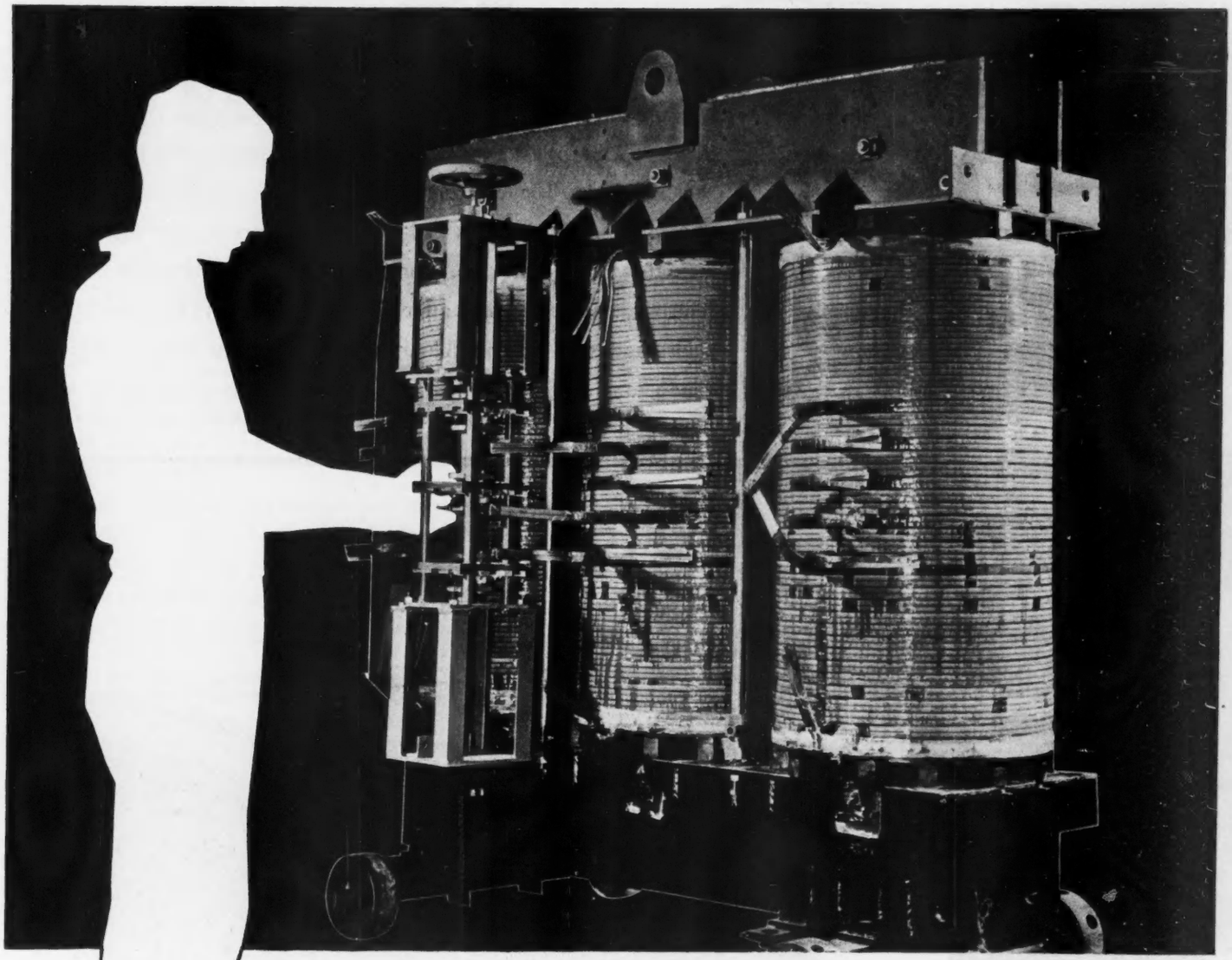

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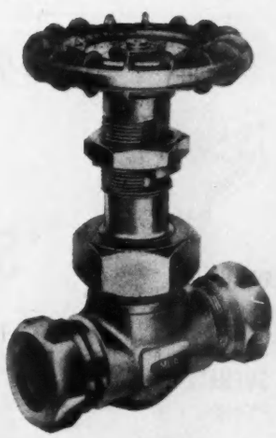

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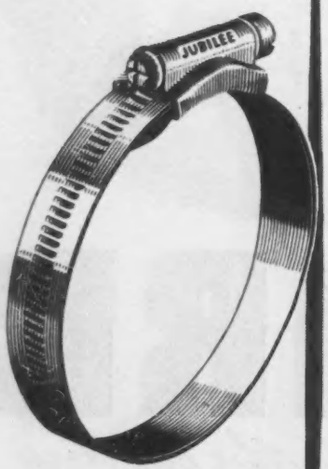

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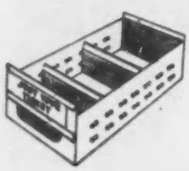

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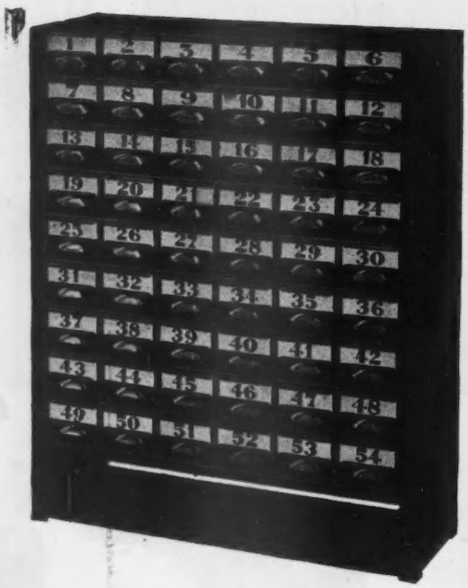

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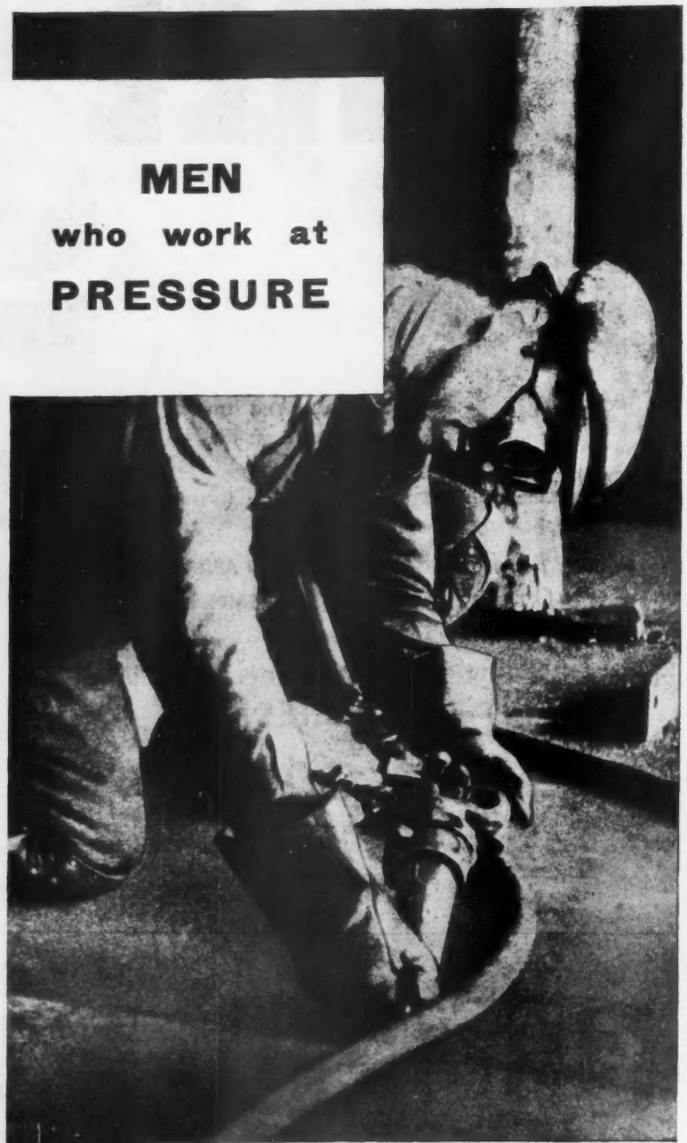

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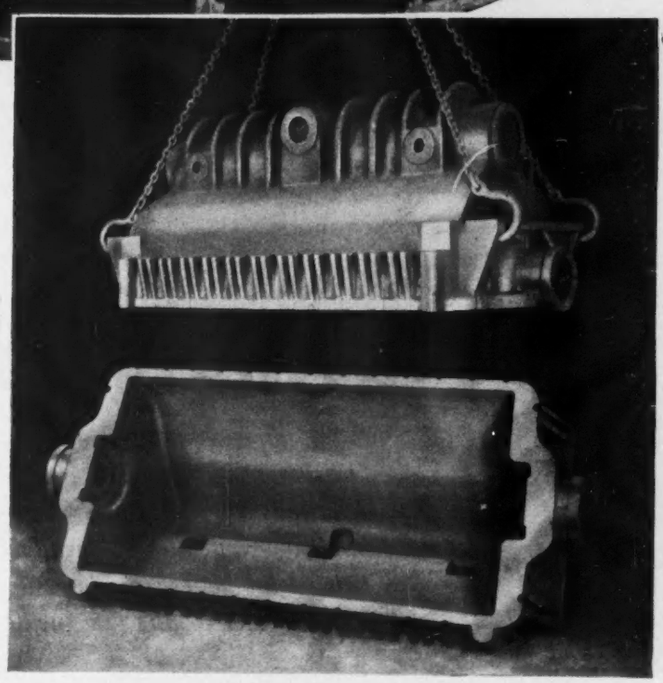

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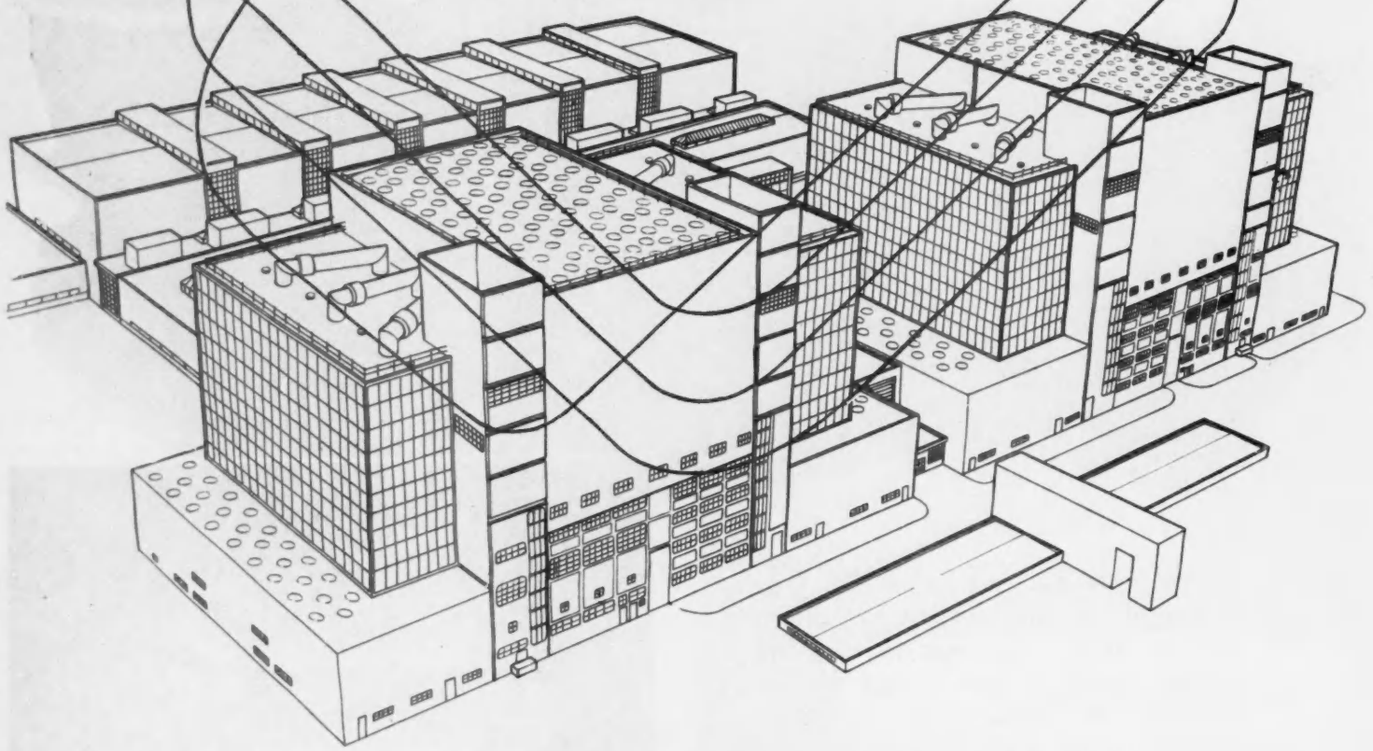

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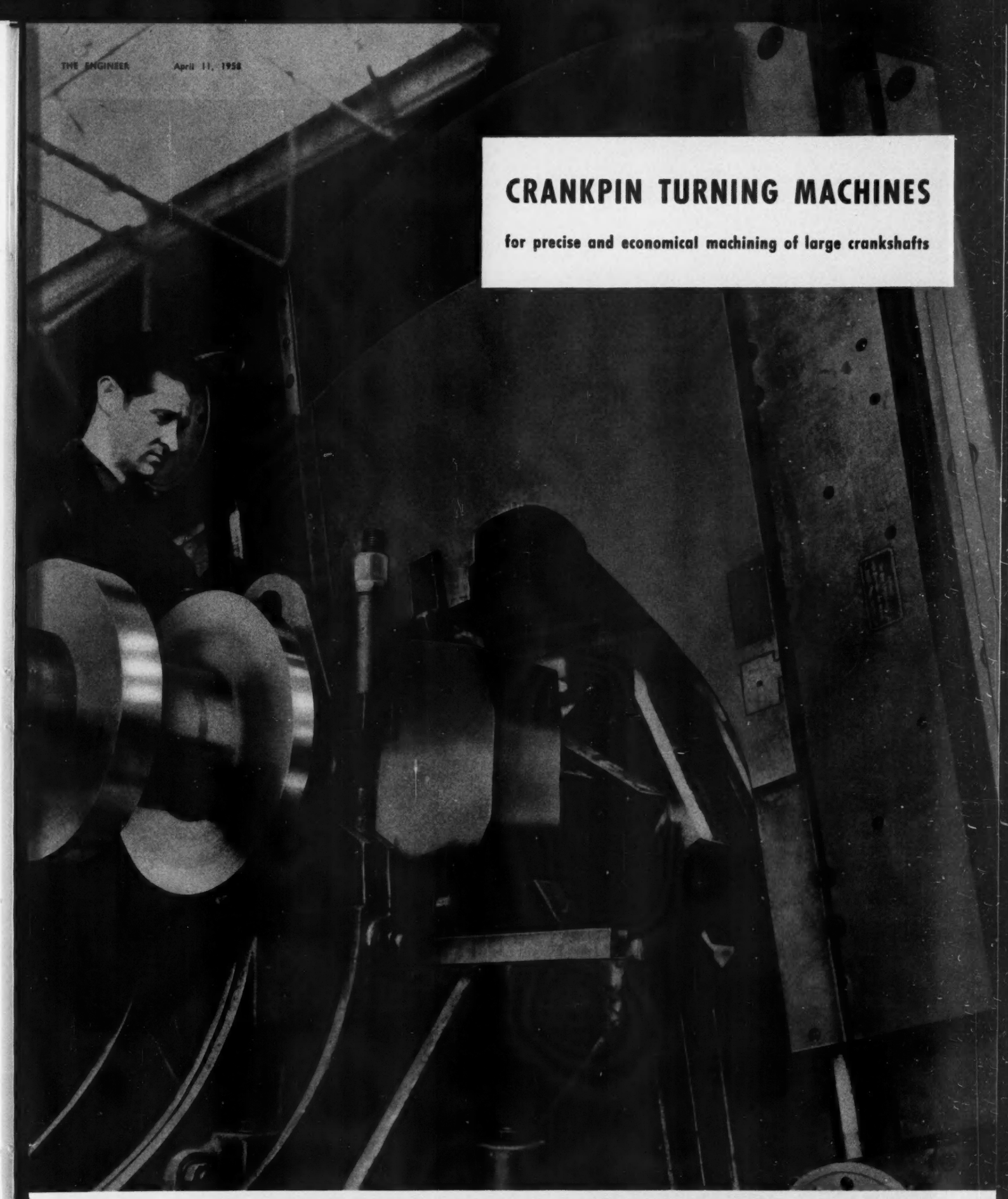

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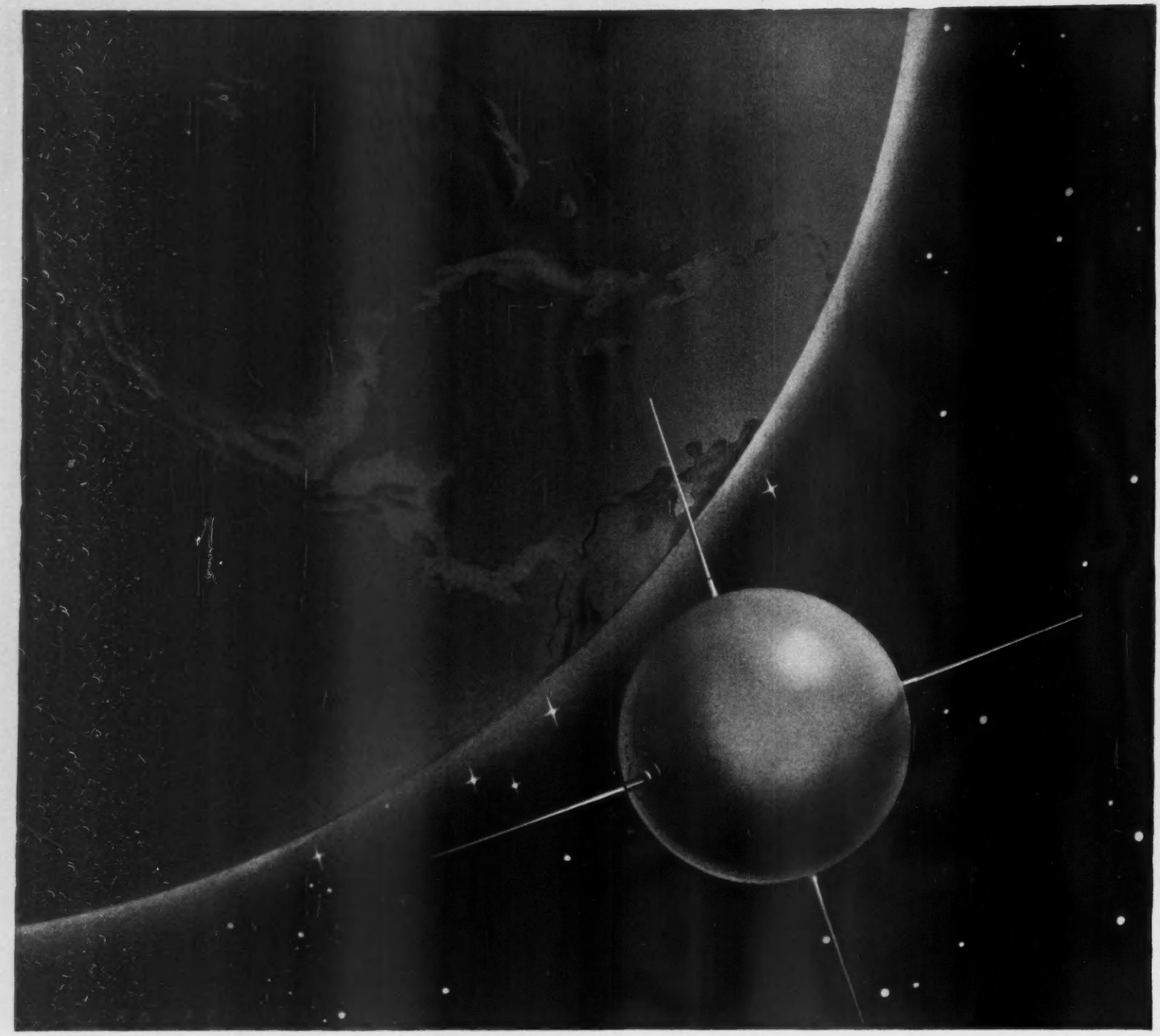

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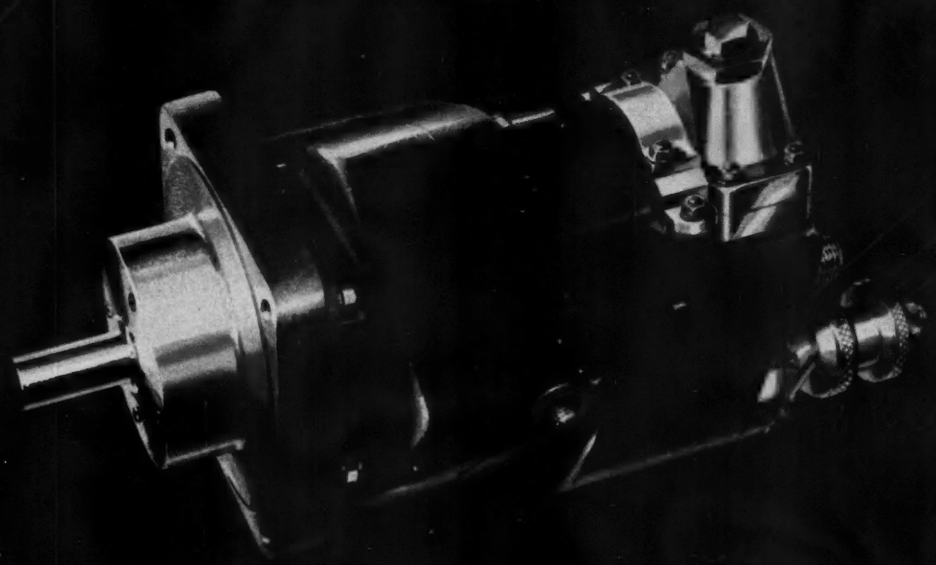

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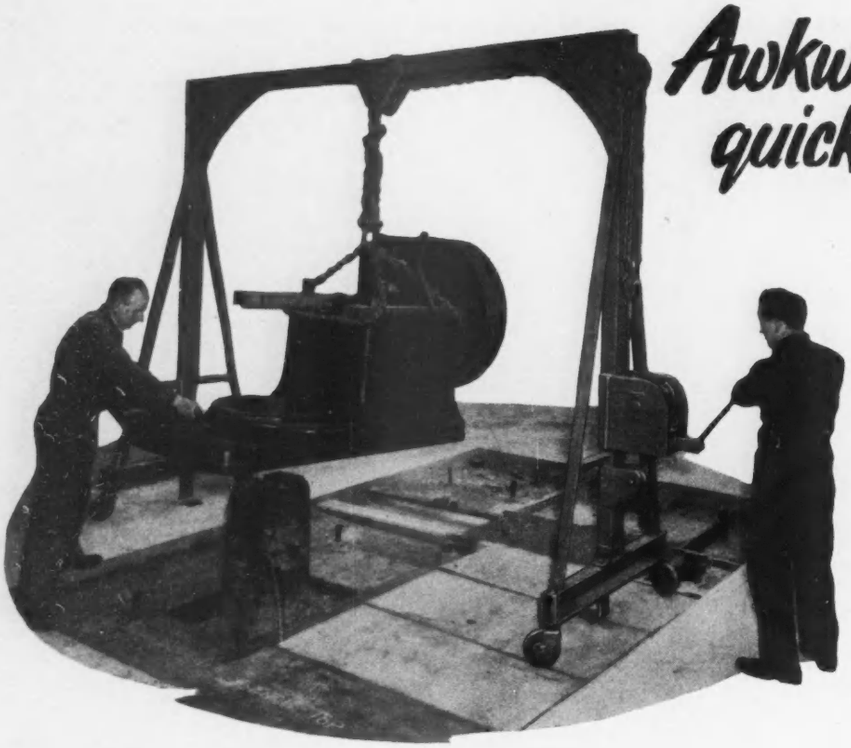

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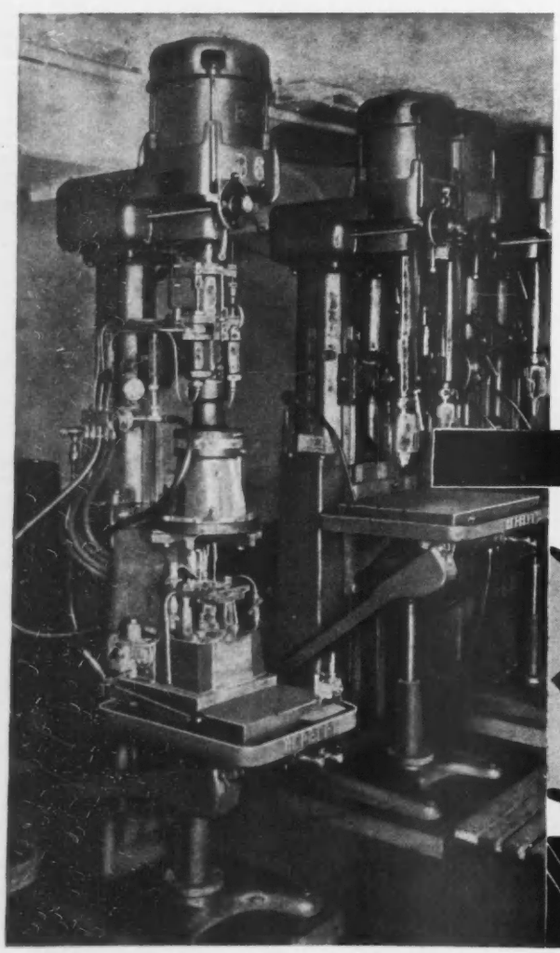

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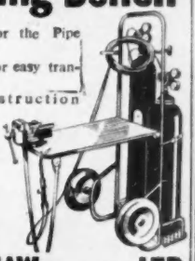

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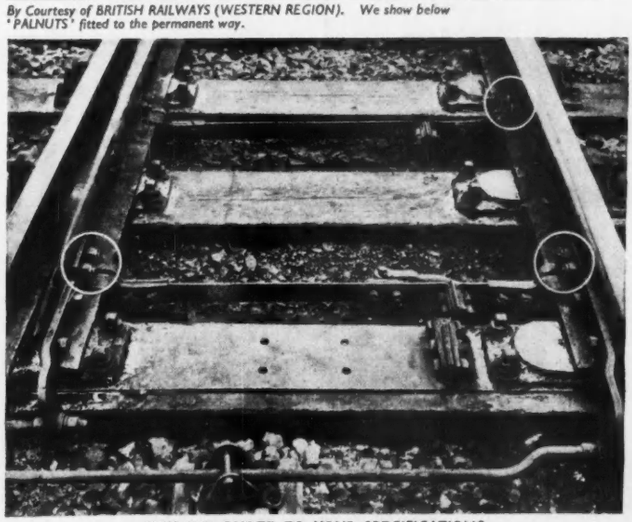

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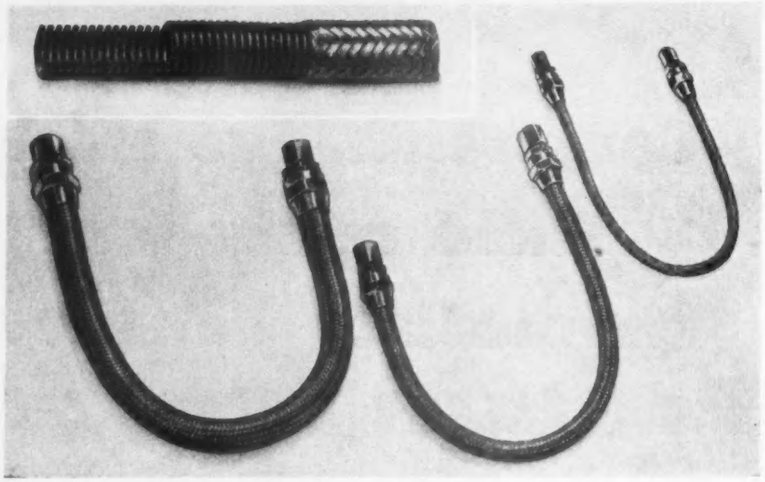

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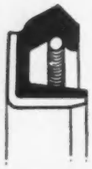

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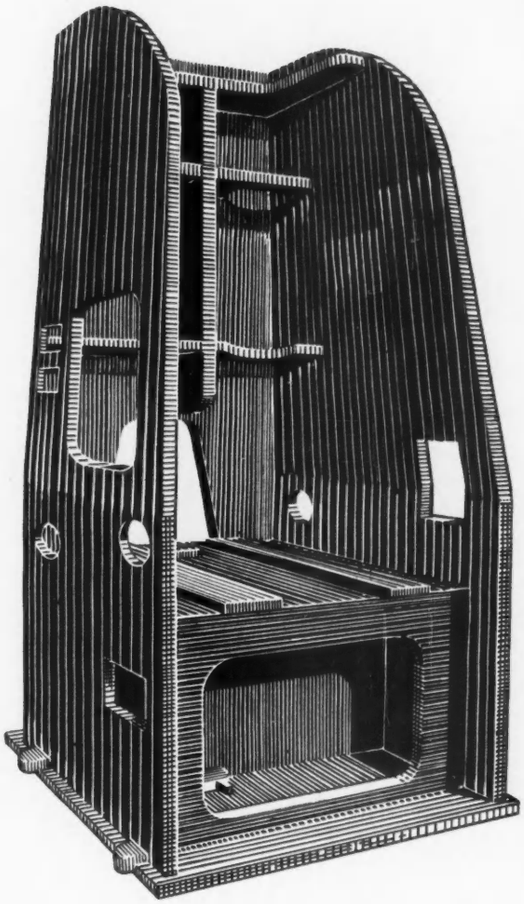

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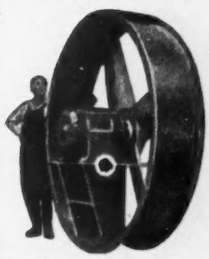

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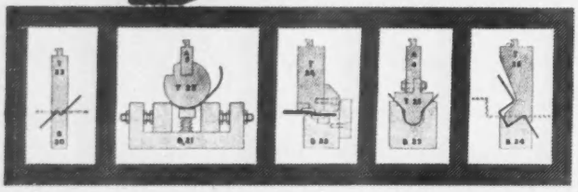

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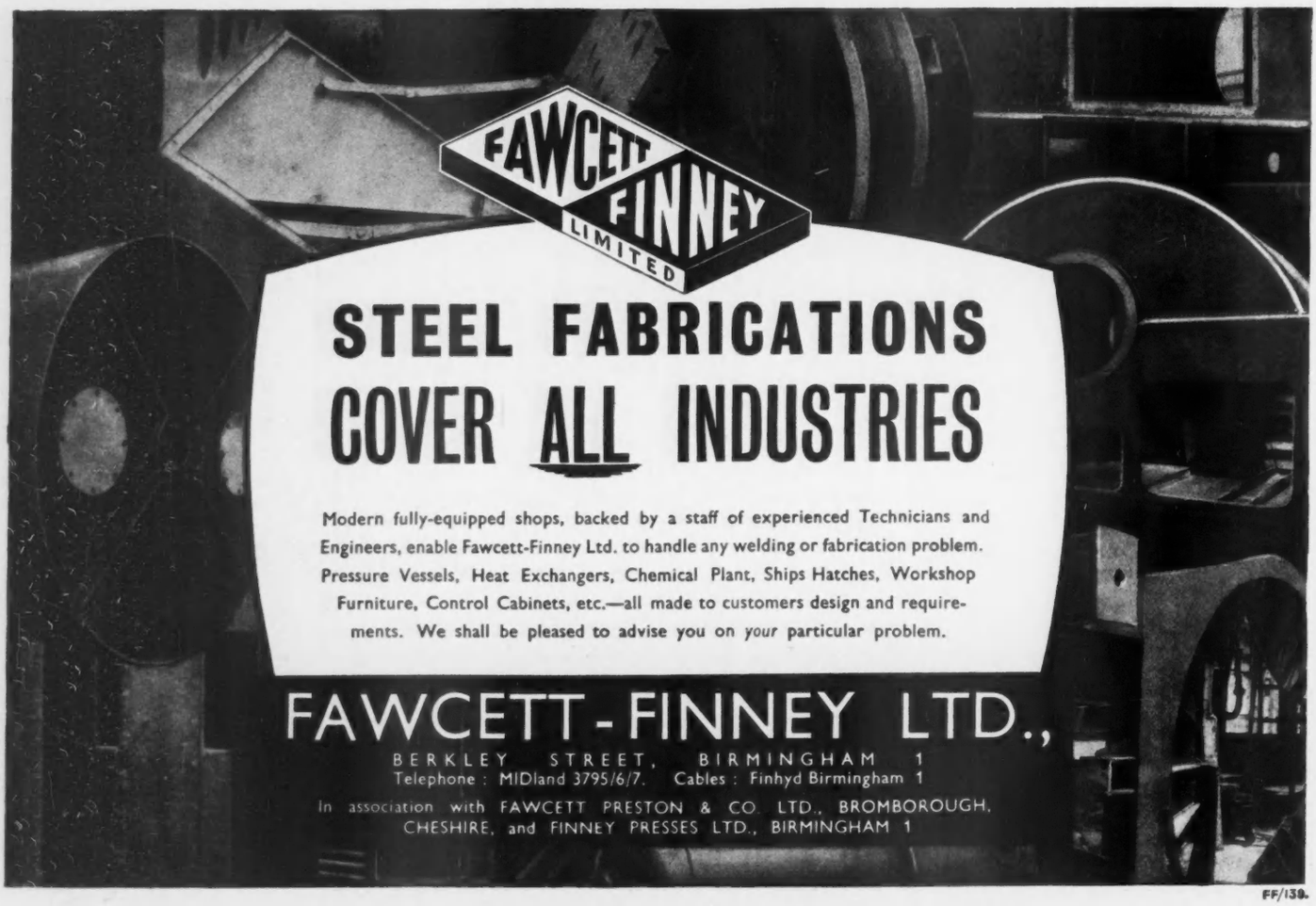

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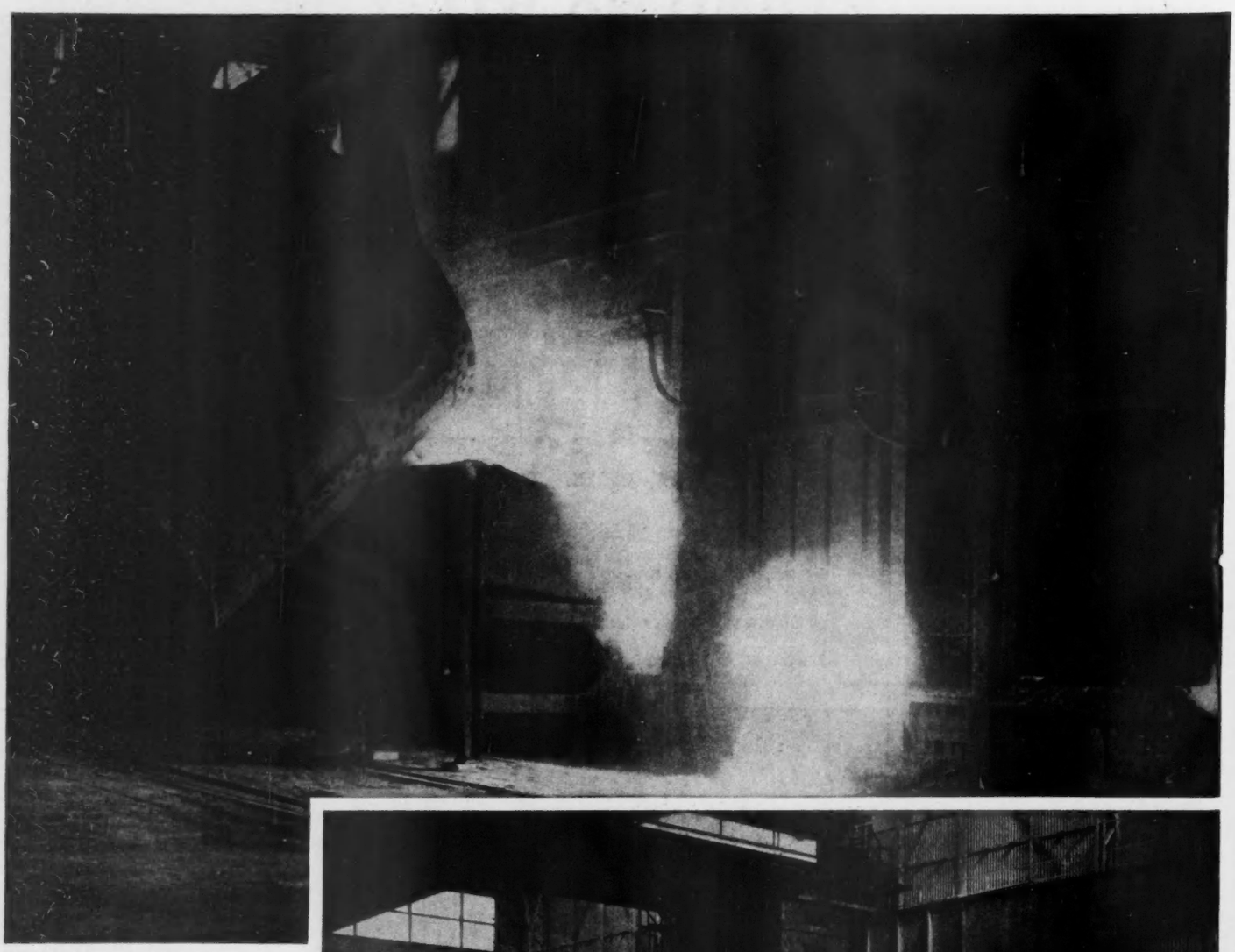

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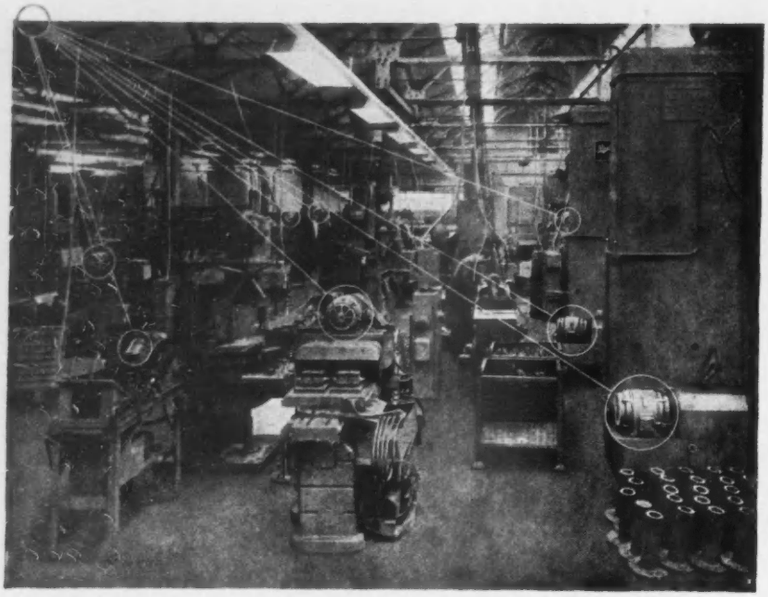

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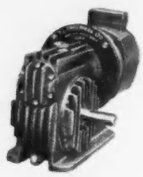

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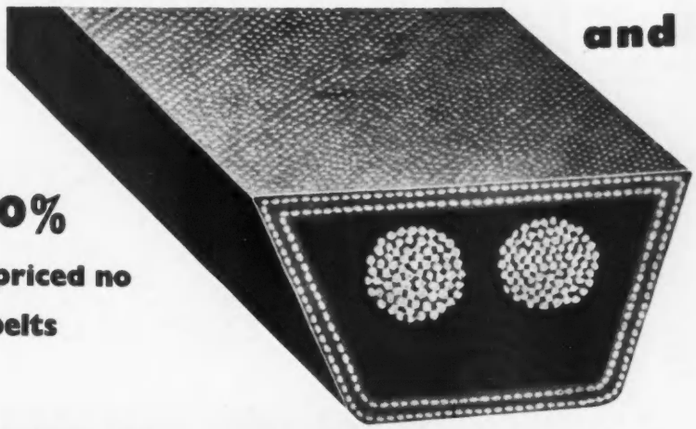

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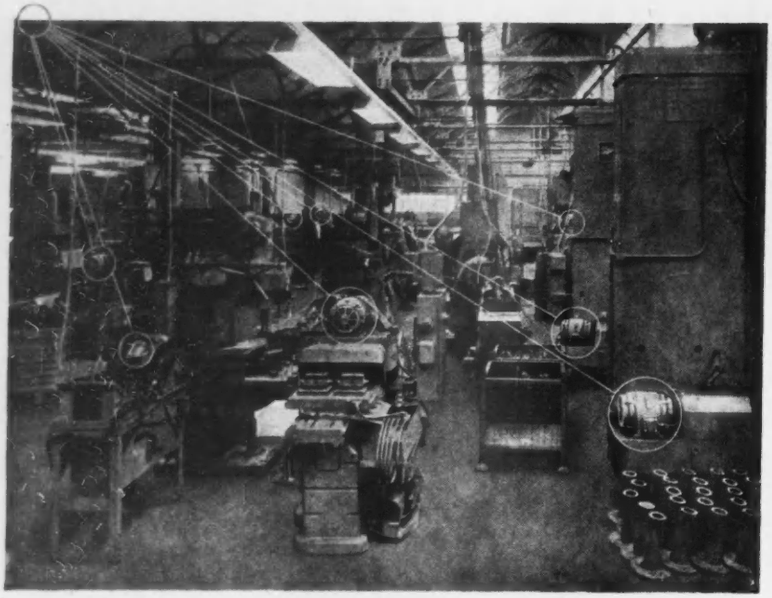

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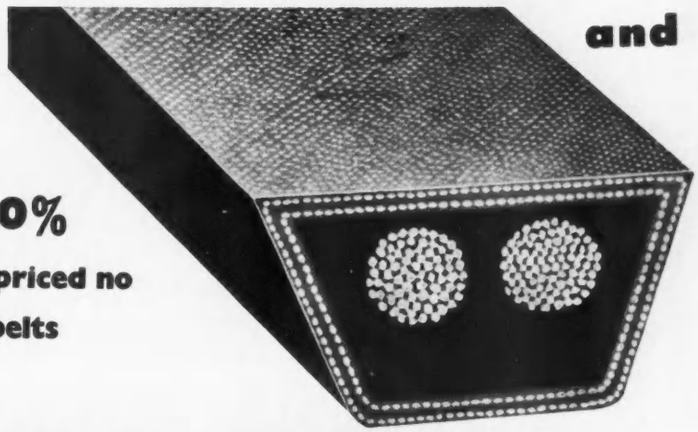
between this  and any other V-belt

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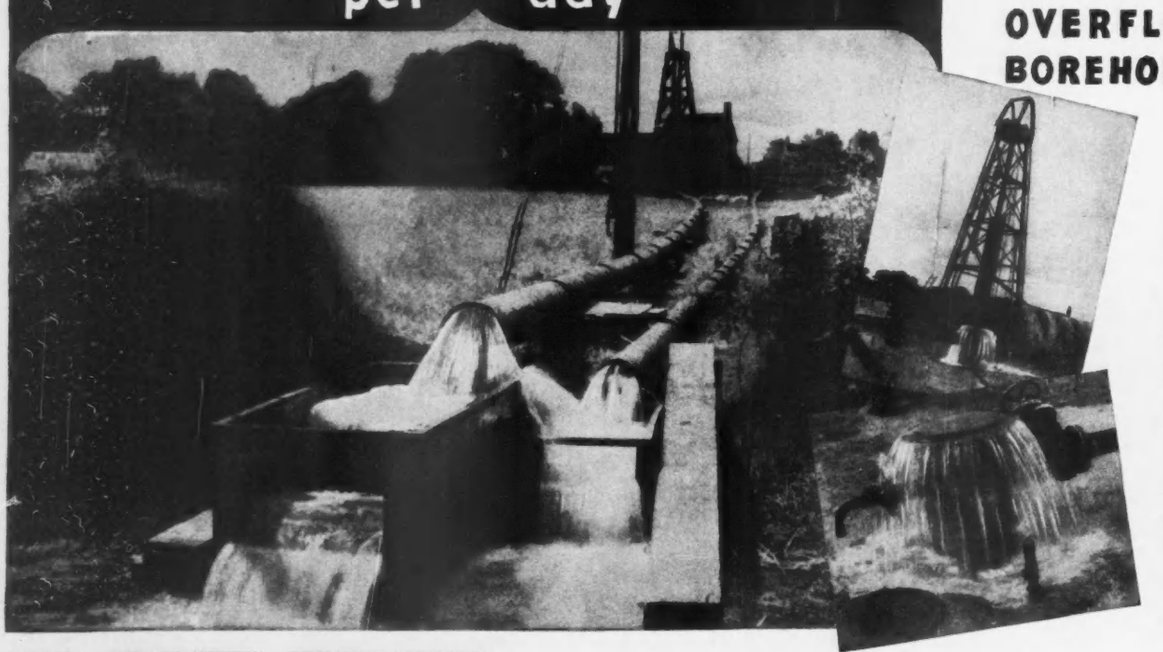

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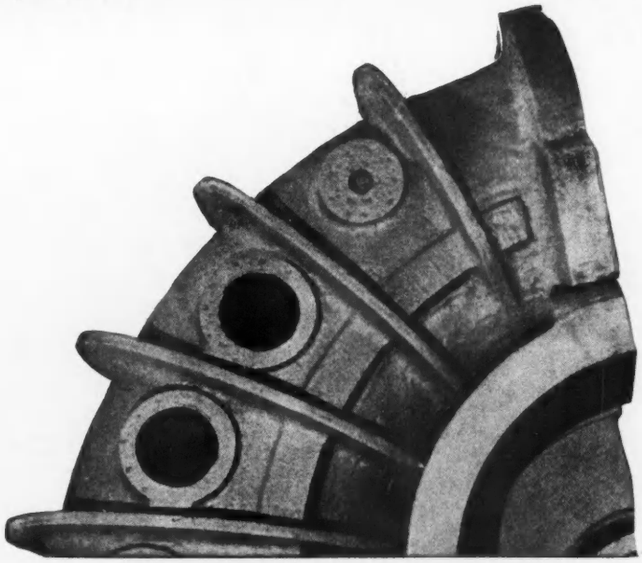
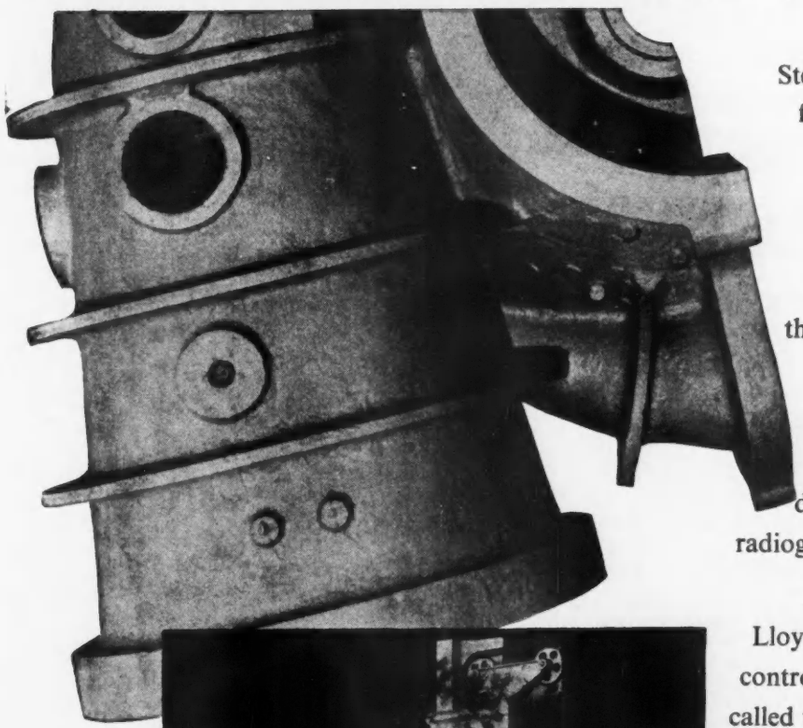


Half gas circulator casing cast in steel and machined for C. A. Parsons & Co. Ltd. for Nuclear Power Station, Calder Hall. Weight as cast 35 tons. Sectional thickness max 7" min 1½". Reproduced by permission of C. A. Parsons & Co. Ltd.

cast and machined for an important part



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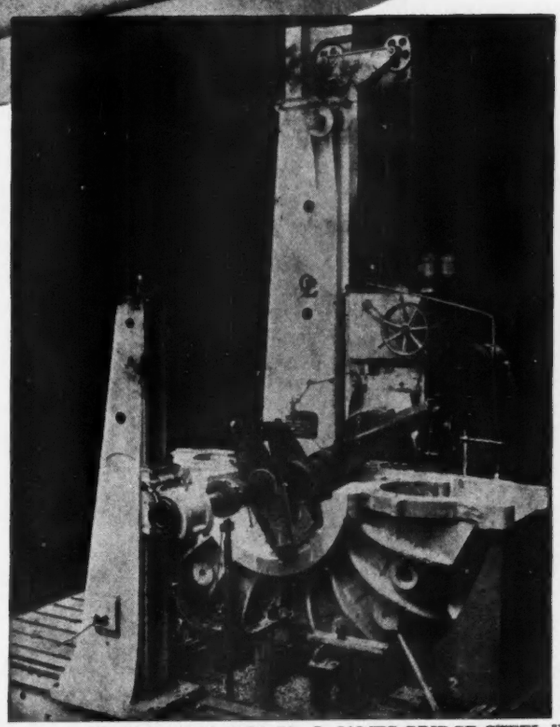

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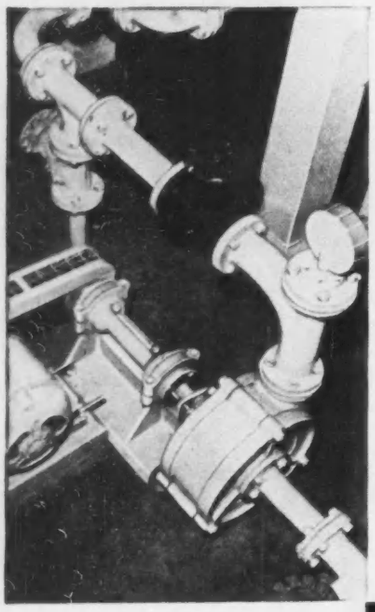

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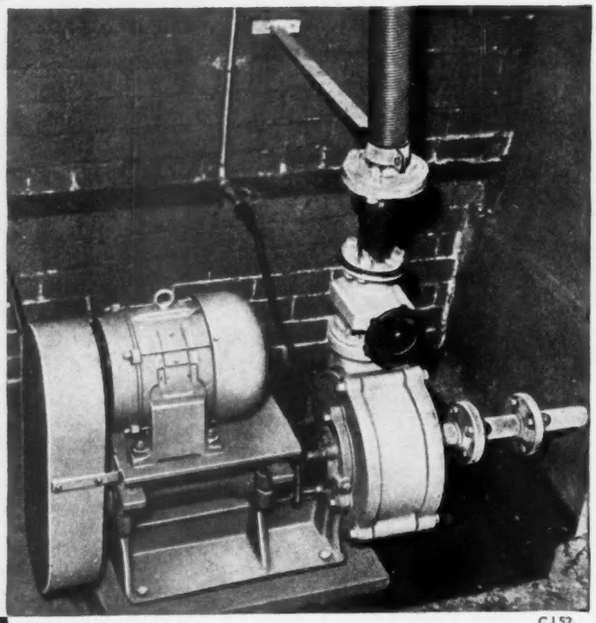

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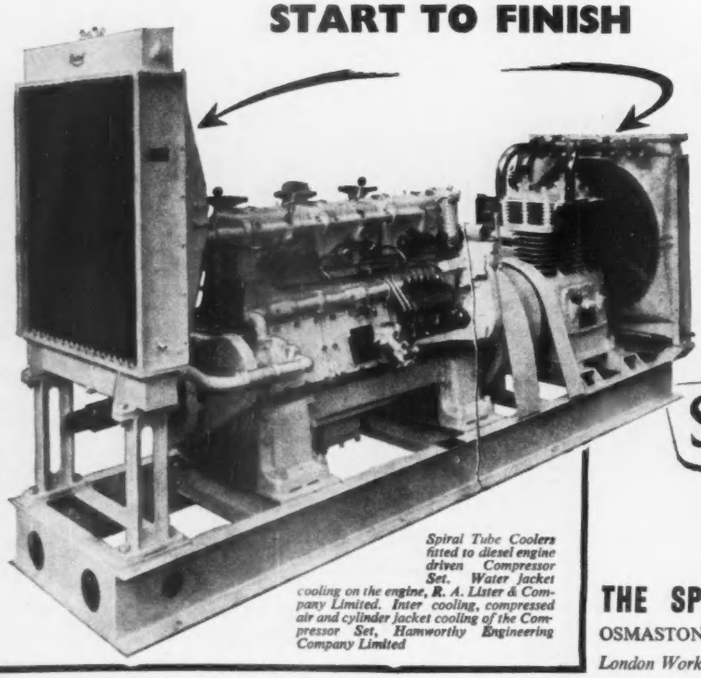

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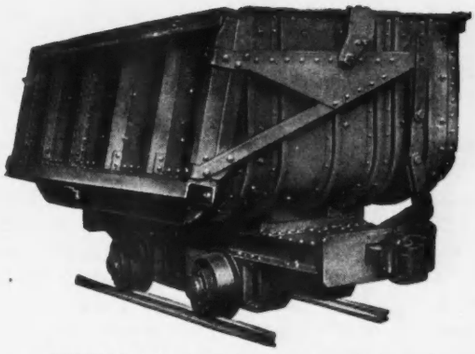

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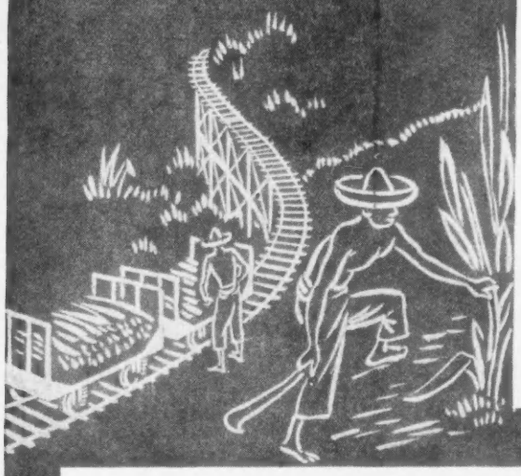

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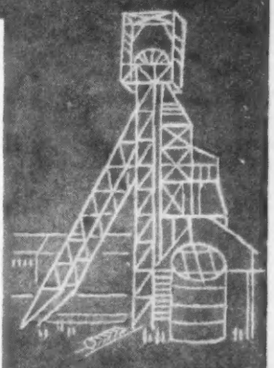

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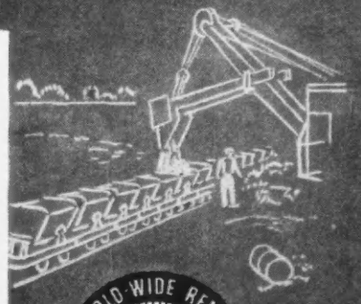

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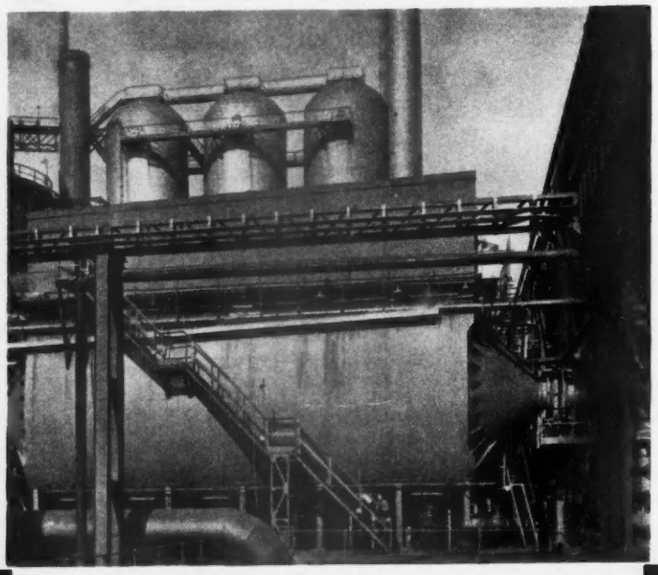

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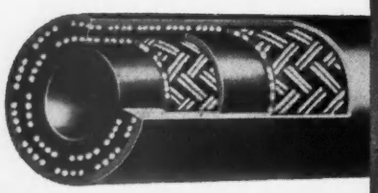

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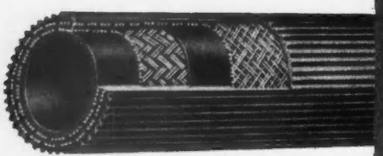

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THE ENGINEER

No. 5333 APRIL 11, 1958 VOL. 205

POWERS OF RIVER BOARDS

Under the Rivers (Prevention of Pollution) Act, 1951, River Boards, before using certain powers conferred upon them to prosecute those who pollute rivers, must obtain the consent of the Minister of Housing and Local Government. That requirement, intended to run only for seven years, was written into the Act because the Rivers Pollution Prevention Sub-committee of the Central Advisory Water Committee, studying the matter in 1949, feared that River Boards might start proceedings which, however desirable in preventing pollution, might clash with the over-riding national interest at that time in the rebuilding and expansion of industries. For the capital available for reconstruction was limited and it was feared that pressure from River Boards, only recently set up at that time and therefore inexperienced, might divert more capital than could reasonably be afforded towards the construction and expansion of sewage and effluent treatment works. Now, the seven years being almost up, the Trade Effluents Sub-Committee of the Central Advisory Water Committee has advised the Minister that there should be an extension from 1958 to 1961 of the period during which River Boards must gain the Minister's consent before taking action. The sub-committee gives as its reasons for reaching that conclusion that " we do not feel that we ought altogether to disregard the fears of those who are concerned lest they be caught between the difficulties of capital restriction on the one side and possible prosecution on the other " and that " a little extra time should be given to industry to pursue their research on effluent treatment and to River Boards to push ahead with the preparation of by-laws ..... "

We confess we find the sub-committee's advice pusillanimous. It merely puts off for another three years the day when a decision will have to be reached as to whether the Boards are really to become responsible for the conditions in their rivers or are to remain for ever hampered by the possibility of Ministerial veto upon the use of their powers. For it is to be noted that the arguments used by the sub-committee in justification of its advice are likely to prove peculiarly irritating to Boards which are no longer inexperienced. There never will be, nor could be, a time when there will not be conflicting opinions as to whether capital can be " afforded " for effluent treatment plant ; there never will be a time when researches into effluent treatment will have been wholly completed ; and it is certainly very doubtful whether River Boards ever will be able to draw up by-laws along the lines conceived by the 1949 " Hobday " Committee owing to the difficulty of devising a suitable general test for toxicity. Thus, if these are the grounds on which the Boards are to be deprived for a further three years of the rights to use their powers without the need for ministerial consent exactly the same arguments can be used into the indefinite future to deny them those powers for ever ! It seems plain to us, now that many River Boards are over ten years old and no longer inexperienced, that either they should be trusted to act temperately and moderately and thus be assigned the full powers which Parliament wished them to have, or that it should be accepted that the Minister should indefinitely have over-riding powers. Of these two courses, it also seems to us that the former is much the more desirable. For, at least in the opinions of those to whom it is a matter of great interest that the rivers of this country should become less rather than more polluted, the effect of the ban upon River Boards taking independent action has been bad. Under the present set-up, which the sub-committee wishes to continue, it is a troublesome and time-consuming matter to prepare a case, not for submission to a court of law, but to the Minister ; and there is no certainty, even if the case is a " cast-iron " one in law, that the Minister will not withhold his consent. Thus, a Board is unable to exert effective and immediate pressure upon an offender polluting the river and more particularly it is denied any effective ability to deal immediately with occasional and careless offenders. Knowing how troublesome it is to get the Minister's consent, Boards are likely to continue to accept any evasive promise of action that may alleviate pollution rather than stand out to get something really firm. The consequence is that those whose interests are likely to be damaged by pollution lack faith in the powers of the Boards to protect them.

Industry has reason to dislike the Anglers' Co-operative Association, some of whose actions seem to the firms and authorities attacked to have been unnecessarily aggressive. But the fact that that body was created and has been supported indicates, so it seems to us, a growing public awareness that there is, in general, no need to pour insufficiently treated effluents into rivers and estuaries and that treatment is difficult or unduly costly only for a limited number of industries. There is a growing awareness, too—amongst enlightened firms and organisations as well as more generally amongst the public—that anyone damaging a river should be liable to be called upon to pay for the damage and to prevent any recurrence, just as anyone damaging another's property should pay for the damage. That is, indeed, we imagine, the fundamental basis of the Common Law affecting rivers to which the Anglers' Co-operative Association has been successfully appealing. The sub-committee is to make a study of the operation of Common Law as it affects river pollution, perhaps with the idea of appealing to Parliament to have it altered. But, in our view, it would be much more to the point to give to the River Boards the powers that Parliament intended them to have ! For then there would be the less reason for those affected by pollution to appeal to Common Law. Nor do we believe that the Boards would use their powers as unsympathetically to

industry and to local authorities as the users of appeals to Common Law sometimes do now. Indeed, we suspect the nation would benefit (industry no less than anglers !) were the River Boards to begin appreciably to reduce pollution by persuasion rather than by force, as they could were they able at need to call upon the force of law to compel the co-operation of the intransigent. For were the economics of water pollution studied as fully as the economics of air pollution, it might well be found not only desirable as an amenity that rivers should be clean but economically worth while as well. Industrialists who exclaim against the costs of effluent treatment might do well to consider that if rivers were not polluted supplies of pure water might well be more cheaply obtained.

WHO SHOULD BENEFIT ?

In almost every issue of this journal we publish one or more articles contributed by authors outside this organisation. We seldom buy the copyright in those articles. We pay fees to the authors for the privilege of publishing the articles before they are published elsewhere ; and because they constitute contributions to technical knowledge we hold it right that the authors, as holders of the copyright, should subsequently be free to publish again elsewhere should they think so fit. To that end we are willing to help by preparing reprints cheaply or by the sale of our blocks or of the drawings prepared in our drawing office from the originals supplied by the authors. We do not in such circumstances demand acknowledgment of prior publication of such articles. We merely request it as a courtesy.

But in the matter of payment for articles a custom is growing to which we think there are strong and solid objections. What happens is this. We accept for publication an article sent to us by an author employed by a Ministry or by some Government-controlled establishment. In due course the article is published and subsequently a cheque is sent to the author. A day or two later the cheque is returned to us requesting us to make it payable to the Ministry or to the establishment, crossed a/c H.M. Paymaster General. The idea is obvious enough. The author of the article did the work upon which it was based, and its writing up, in the ordinary course of his employment. In consequence it is felt that he ought not to benefit. We have no desire to " lay down the law " as to whether that attitude is right or wrong. It is a matter for each establishment to settle for itself. What we do ask is whether it is right for the establishment in such circumstances to ask that the fee should be transferred to it ? At a first glance it appears reasonable enough. For it seems that the employer is receiving payment for work his servant has done in the ordinary course of his employment. But here, surely, a distinction should be drawn between an ordinary employer and a Government establishment. For a Government establishment is set up to serve the public, at the public expense. If it is part of its duty to conduct researches and to collect new knowledge it is also its manifest duty to see that new advances in knowledge thus acquired are made public, as quickly, cheaply and effectively as possible—unless, of course, national security is involved. Broadly there are three methods by which the establishment can perform this duty. It can get an article printed in the technical press ; it can get a paper accepted for presentation before an Institution ; or it can get H.M. Stationery Office to print the material. Of these methods the last is likely to be the most expensive since H.M. Stationery Office cannot hold it at all likely that it can meet its costs upon the publication of a document of limited specialist technical appeal. Moreover the publication of technical material is of such high importance to the prosperity of the nation that the charge made for such a document ought to be as low as it can be made. Yet, as a last resort, this is the mode of publication that a Government establishment must try to adopt if it is to carry out its manifest duty to publish. In these circumstances the special privilege, if any, accorded to a technical journal which agrees to accept an article for exclusive prior publication seems to us more than balanced by the benefit of costless publication conferred upon the establishment and the nation. The journal concerned is, in fact, serving an essential purpose of the establishment and helping it to perform its national function.

Two arguments are sometimes used to justify the claim of an establishment to receive the fee. The first is that as the journal is published commercially it ought to pay someone for the article. This is clearly irrelevant to the point at issue, which relates to the plain duty of the establishment to get the material published somewhere. It is also irrelevant because the journal concerned has no objection to paying a fee to an author for the work he has done in writing up the material. Furthermore it is inconsistent with Government practice in other fields where advice, information and instruction are given to commercial firms, without charge, in the national interest of, for example, encouraging exports. Lastly it is somewhat offensive. For no editor is going to consider in relation to a particular technical article whether it will be financially profitable or otherwise to publish it. We, like other technical journals, publish quite a few highly specialised articles with very limited readership appeal. It is our duty. For few other bodies could afford to do so. The second argument is that Crown Copyright is involved. Here there arises a much larger and thornier question. We are always happy to acknowledge Crown Copyright. But as it seems to us to be the manifest duty of a Government establishment in the national interest to make technical knowledge as cheaply available to the public as it can be made, we strongly object to paying for it. Nor, since we, together with the rest of the nation, pay taxes to support the activities of a Government-controlled establishment do we see why the establishment should be paid a second time —by us—to do its national duty. This principle of free publication in the national interest is fully recognised in certain fields to which Crown Copyright is applied e.g. to all documents laid before Parliament. In our view it should apply in the national interest to all technical material too. There is one obvious exception. If a journal commissions an establishment or someone within it to write an article or take a particular photograph, &c., work that it cannot be said to be the duty of the establishment to undertake, the establishment clearly can reasonably require some payment for the special service rendered. But that is a special case with which we are not here concerned.

In conclusion we hasten to acknowledge the diversity in practice about this matter in Government-controlled establishments. Only a few appear to act in the manner described. Some advise us that no payment should be made ; some permit us to pay a fee to the authors—though, it may be, some private internal arrangement of which we have no knowledge is involved. For our part we tend to feel it to be so important that research workers and others should be encouraged to undertake the often laborious work of writing up their results in a

readable and useful form that an embargo should be placed upon their acceptance of fees for this work only in exceptional circumstances. We have no desire to withhold the fee. We merely do not understand why we should be expected to pay it to a Government-controlled establishment for doing what is the plain duty of the establishment to the public as a Department of State. That, it seems to us, is to impose a special and objectionable form of taxation upon the technical press, in addition to the taxes it already pays in support of other such establishments whose work is of no direct interest to it. Lastly it should be noted that these arguments do not apply to the work of industrial research associations. For there is no duty laid upon those bodies to publish their discoveries in the national interest. Their primary duty is to the industries they serve; their primary financial support comes from those industries. We cannot in those circumstances object to the transference of a fee from the author to the organisation.

BRITAIN'S VIRILITY

If one were to judge by much that has been written about this country since the war there is very little hope of its economic survival for very much longer! Every day one reads or hears complaints, amongst other things, that the British workman no longer knows how to work, that trade unions resist the introduction of any and every labour-saving device, that unofficial strikes occur for any reason or even none at all, that the whole system has become so rigid that workpeople will not move from one firm to another nor from one industry to another, and that the inhabitants of this country are really interested only in getting something for nothing through the social services. No wonder one occasionally encounters, abroad, the strange view that Britain is "finished" as an industrial nation and as a great power, intellectually and scientifically. For not everyone else in the world understands that it is a national pastime for Englishmen, even more than for Scotsmen, Welshmen or Irishmen, to criticise themselves; nor do they realise at all fully that this self-criticism often pays high dividends. For competitors are sometimes led to believe from it that we really are backward technologically and lacking energy in salesmanship. The truth is, we believe, this nation is only backward in entering a new market with a first-class product when established markets are already absorbing as much as it can produce! It then adversely criticises itself for not entering that market! A few months ago a Canadian Trade Mission came to this country, many of its members believing, as so many people across the Atlantic do believe, that over here we are falling into "the sere, the yellow leaf." That Mission went back to Canada so full of admiration that to "capitalise the interest generated in that mission" the dollar-sterling trade council in Canada is now to be expanded by the addition to it of members of the Mission and by the creation of six regional committees in Halifax, Montreal, Toronto, Winnipeg, Calgary and Vancouver, dedicated to the expansion of British-Canadian trade.

It is only our habit of public self-criticism which makes our situation seem desperate to people from other lands. Amongst the real facts one may notice that in manufacturing industry production per man employed has risen by some 25 per cent since 1948 and average hours actually worked per week have risen from 44·9 in 1948 to 45·9 in 1957. The time lost by strikes we particularly delight to exaggerate. In fact, it amounts each year to about one-tenth that lost through industrial accidents and one-hundredth that lost through sickness. Very few countries show smaller figures. As for the supposed rigidity of our economy it is not easy to discover where it lies! For example, between 1948 and 1957 employment in electrical machinery and scientific instruments increased by one-fifth, in machine tool manufacture by two-fifths, and in aircraft manufacture and the radio industry by four-fifths. By contrast, employment in cotton spinning and weaving fell by a seventh and upon farms by about a fifth. Something of the order of 2,500,000 changes of job take place in manufacturing industry each year, about half of them across industry boundaries. As for our products, many speak for themselves—the first commercial-scale nuclear power stations in the world are now under erection in this country, this country has built every one of the turbine-powered airliners at present in service in the world, and the recent announcements about ZETA revealed how rapidly we are capable of developing a scientific concept towards the technological end of using nuclear fusion as a source of power. But what impressed the Canadians at least as much as this country's products was the manufacturing equipment available to produce them and the evidence of the high rate at which manufacturing capacity is being expanded. Many years ago—the quotation sticks in our heads though we have been unable to verify it—a historian wrote of a period some twenty years after the end of the Napoleonic wars that this country "could no longer conceal its prosperity." It is becoming increasingly difficult, in this age, to conceal any longer from other nations the virility and energy of the British people.

The Engineer — 100 Years Ago (APRIL 9, 1858)

"EXHIBITION OF INVENTIONS"

"The tenth annual exhibition of inventions at the Society of Arts in the Adelphi was opened on Monday last. It presents, if anything, more than the usual interesting features; and considering the limited space afforded by the Society's rooms for any public exhibition, especially one of models or working machines, necessarily occupying much floor or rather counter space, it is remarkable how so many objects have been arranged in so small a compass, and yet so as to allow of free access to each. By a new and judicious arrangement of the tables upon which the models etc are displayed, and by appropriating the entrance hall, as well as the staircase and every available nook, nearly four hundred articles, inclusive of drawings, have been conveniently disposed for examination, reflecting much credit upon those to whom the exhibition arrangements have been entrusted.

"Taken as a whole, the collection consists strictly of new, or at least recent inventions, although in a few cases we notice the introduction of contrivances which have already made their *début*, and upon the selfsame stage upon which they now appear. It would doubtless be an exceedingly difficult, not to say a very unpleasant task, to criticise, with a too rigid scrutiny, the novelty of every model sent to the Society's rooms; and we must confess that had we ourselves a duty to perform so onerous as to make a selection from the things sent in for exhibition, we should occasionally be disposed to treat with leniency those who presented inventions to us, although we might recognise some old acquaintances, especially if arranged not in ordinary garb, but in new colours and under new names. At the same time no one will deny that the objects of the annual exhibitions of the Society should not be prostituted to the mere purposes of advertising inventions, however useful and successful they may be, if they do not fall within the category of 'articles recently invented, patented, or registered,' described in the Society's catalogue as constituting the collection."

Silicone Insulation for Traction Motors

London Transport has been doing extensive experiments in the use of silicone materials instead of mica-based materials for the insulation of armature windings in traction motors and other equipment on Underground rolling stock. Ten years' experience has yielded encouraging results offering the promise of prolonged armature life, improved reliability, cheaper maintenance, and reductions in motor weight. Accordingly, it has been decided that a proportion of traction motors on new Underground rolling stock should be insulated with silicone materials, for long-term comparison with more orthodox insulants. Silicones will also be used for all rewinds that may be necessary on "Metadyne" machines, which are used for traction control in certain classes of rolling stock.

FAILURES in traction are usually attributable to thermal ageing of the insulation and to consequent carbonisation and tracking. But silicone materials* have been found to be superior to organic insulating materials in their chemical structure, in their ability to withstand high temperatures and in their resistance to thermal ageing. Moreover, when these silicone materials do decompose the products of decomposition are not electrically conducting.

For these reasons development was started in 1948 at the central railway overhaul works of London Transport to produce a satisfactory silicone-insulated traction motor. The main objects of the work were, first, to develop an improved insulation for existing and future traction motors and other machines, and secondly, to gain experience in the production techniques that might be needed in using these materials. The traction motor chosen for tests with silicone insulating materials was the "LT.100" motor. This machine, which was designed in 1938, is basically similar to the traction motors being designed to-day, and it was chosen because of the large number in service. It is a 168 h.p. (one-hour rating), 600V, four-pole machine, with a wave-wound armature having thirty-one slots and five conductors to each slot. The armature slot space factor is higher on this motor than on any other in service on London Transport's railways, and this fact ensured that if silicone insulating materials were satisfactory on this type of machine, it would be possible to use them on other machines where the armature slot space factor was lower.

When the tests were started the only silicone compounds suitable for motor insulation were the silicone resins which could be used in place of organic varnishes in combination with woven glass and mica. For this reason the method of insulating the first motor for test was to substitute woven glass tape and silicone varnish for the paper and shellac which were used in the existing method of insulation. Three of the armature conductors were insulated with a half-lapped layer of glass mica tape bonded with silicone varnish, but to obtain the required armature bar dimensions it was only possible to apply a butted layer on the remaining two. The earth insulation consisted of silicone bonded glass mica tape wrapped round all the conductors, and this was retained by a half-lapped layer of white glass tape. At each stage of insulation the armature bar was painted with silicone varnish and finally it was pressed in a hot press to cure the varnish. The use of the hot press introduced production difficulties, which led to the abandoning of this method of insulation in favour of further tests on the then newly introduced silicone elastomers. One armature (Fig. 1), however, was insulated in this way and began service in November, 1952. In December, 1953, it was withdrawn from service because the ventilating fan had broken and the opportunity was taken to return it to service without the fan, so that the running temperature would be raised; this motor is still running in this condition and no defect has developed.

In 1952, semi-cured silicone elastomer materials were introduced into this country, and between 1953 and 1955 four "LT.100" traction motors were insulated with these materials in combination with silicone bonded glass mica tape. The insulation of these armature bars was silicone bonded glass mica tape on the individual armature conductors and an outer layer of semi-cured silicone elastomer coated glass tape to act as earth insulation. This semi-cured elastomer was later cured in an oven to bond the layers of tape to form a sheath round the armature bar. The armature bar was completed by an outer wrapping of white glass tape, which was afterwards varnished with a silicone varnish. Two of these machines were also fitted with field coils (Fig. 3) insulated with silicone bonded flexible mica between the turns of the coil, and an outer wrap of semi-cured silicone elastomer coated glass tape, covered with a layer of white glass tape and finished with a coat of silicone varnish. The running temperatures of these two machines were raised by omitting the ventilating fan and blocking the armature core ventilation ducts.

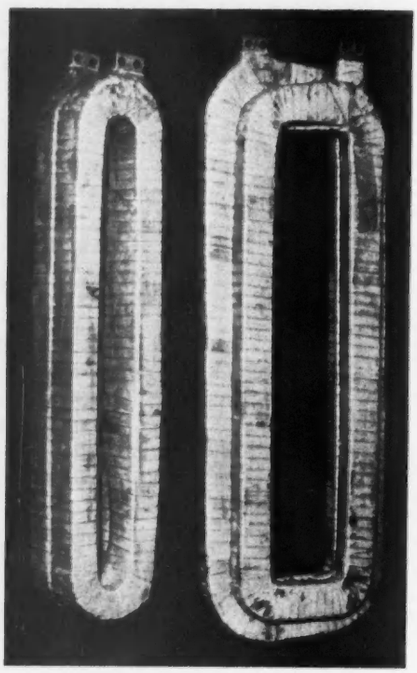


Fig. 3—"LT.100" traction motor field and interpole coils with semi-cured silicone elastomer glass tape

During manufacture of these armature bars it was found that on occasions the silicone elastomer failed to cure. Silicone elastomers require very careful temperature control during the curing operation, the later stages of which must be carried out in the presence of oxygen, otherwise the cure will be inhibited. It is necessary to use a two-temperature curing cycle—first at a lower temperature to initiate the cure and then at a higher temperature to complete the cure. If too high a temperature is used too soon, bubbling and sponging may occur. As some of the semi-cured materials are also sensitive to contamination by organic substances, their use presents production

* A silicone is a silicon-organic compound based on a silicon-oxygen structure with hydrocarbon radicals bonded to the silicon atoms. For electrical uses the most important forms of silicones are the silicone resins and elastomers.

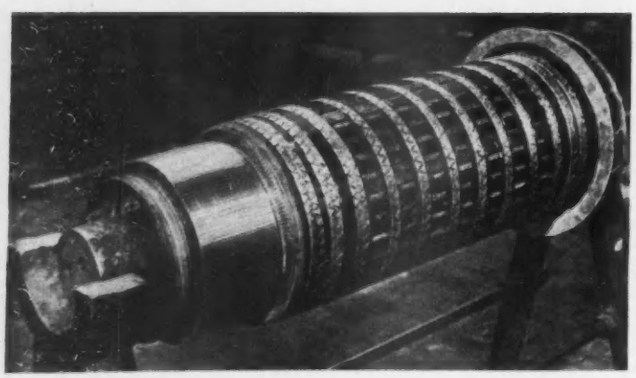


Fig. 1—An "LT.100" traction motor armature insulated with silicone bonded glass mica. This armature is shown with the ventilating fan fitted

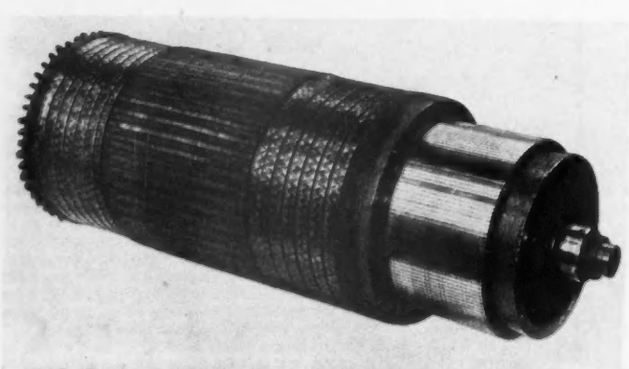


Fig. 2—A "Metadyne" machine main armature insulated with glass mica and semi-cured silicone elastomer materials

problems which are difficult to overcome without special equipment.

Early in 1956, one of the four machines which was insulated with a combination of glass mica tape and silicone elastomer failed with an armature insulation defect. Examination of the machine indicated that in spite of the severe arcing which had taken place at the point of failure, the surrounding insulation remained in good condition and showed no sign of carbonisation under the intense heat. Examination of the undamaged armature bars showed that the silicone elastomer had failed to cure fully, with a result that when the armature bar was fitted into the armature slot the silicone rubber had been reduced in thickness at the bottom corners. In addition, there were indentations in the silicone rubber under the banding wire, due to the localised pressure at these points. It

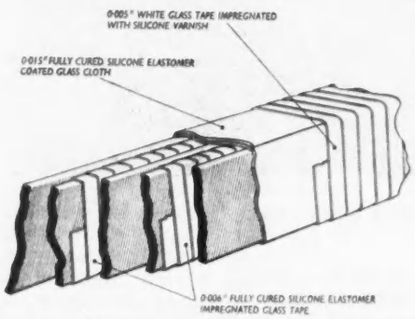

0·005" WHITE GLASS TAPE IMPREGNATED WITH SILICONE VARNISH
0·015" FULLY CURED SILICONE ELASTOMER COATED GLASS CLOTH
0·006" FULLY CURED SILICONE ELASTOMER IMPREGNATED GLASS TAPE

Fig. 4—Slot section of an " LT.100 " motor armature bar insulated with fully cured silicone elastomer glass tapes and slot wrapper

was considered that the reduction in the thickness of insulation at certain points, due to the plasticity of the incompletely cured silicone elastomer, was the cause of the failure, and it was decided that the use of semi-cured silicone elastomer should be abandoned because of the difficulty of ensuring a proper cure under production conditions. Development work was therefore concentrated on the use of fully cured silicone elastomer tapes for the armature bar insulation. However, the remaining three machines are still running satisfactorily.

By this time silicone adhesives were available and a fully-cured silicone-elastomer-impregnated glass tape was developed which was coated with a thermo-setting pressure-sensitive silicone adhesive. A tape having the desired electrical and mechanical characteristics was produced as thin as 0·006in and it was thought that this would be more suitable than glass mica tape for the insulation of the individual armature conductors. With glass mica insulation on the armature conductors there is a risk of the mica splittings fracturing at the sharp bends on the edges of the conductor, which reduces the dielectric strength of the conductor insulation at these points. By using a silicone elastomer tape, which is flexible and homogeneous, these difficulties are overcome and, in addition, the resilience of this insulation resists damage by vibrational and other stresses occurring in service.

As the minimum thickness of the silicone elastomer glass tape was greater than the thickness of the glass mica tapes used for the armature conductor insulation, it was only possible to insulate three of the five armature conductors, the remaining two being left bare. The earth insulation consisted of two half-lapped layers of silicone elastomer glass tape coated with a pressure sensitive silicone adhesive, and finally a half-lapped layer of white glass tape varnished with a silicone varnish. An armature insulated with this coil insulation entered service in the middle of 1957.

A number of armature bars which were insulated in this way were submitted to laboratory tests which were designed to simulate the effects of centrifugal force and temperature. These tests, which were carried out in conjunction with Midland Silicones,

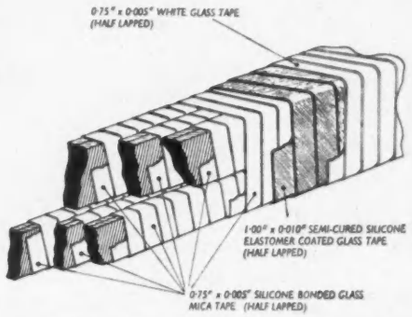

0·75" x 0·005" WHITE GLASS TAPE (HALF LAPPED)
1·00" x 0·010" SEMI-CURED SILICONE ELASTOMER COATED GLASS TAPE (HALF LAPPED)
0·75" x 0·005" SILICONE BONDED GLASS MICA TAPE (HALF LAPPED)

Fig. 5—Slot section of a " Metadyne " machine armature bar insulated with silicone bonded glass mica tapes and semi-cured silicone elastomer

Ltd., and H. D. Symons and Co., Ltd., indicated that the bars were well able to withstand the mechanical stresses likely to be encountered under operating conditions. They were also heated to 200 deg. Cent. for nine days and then to 330 deg. Cent. for twenty-five hours. No adverse effects could be detected as a result of this heating cycle.

Under high tension test it was found that breakdown of this system of insulation occurred to earth as a result of tracking across the adhesive layer. For this reason, and to utilise the available space in the armature slot to its full extent, it was decided to substitute a fully cured silicone elastomer impregnated glass wrapper for the tape which was previously used for earth insulation. This alteration more than doubled the breakdown voltage to earth. It means, however, that only two of the armature conductors can be insulated, leaving three bare (Fig. 4). Twelve " LT.100" traction motor armatures are being insulated in this way and, in order to distribute the pressure under the banding wire more evenly and to prevent local indentation of the insulation, strips of epoxy resin glass laminate are to be inserted between the armature bars and the armature bands. It may be possible, however, to obviate the use of the epoxy resin bonded glass laminate by the substitution of polyester resin bonded glass rovings for steel banding wire.

While experiments were being carried out with the " LT.100 " traction motor, it became necessary to rewind a number of " Metadyne" machines, and more than fifty have now been rewound with silicone insulation. At the time the decision was taken to use these materials, it was thought that the semi-cured silicone elastomers would give satisfactory service, and an armature bar was therefore developed, using this material in combination with glass mica tape (Fig. 5). In fact, this armature bar has given good service, in spite of the silicone elastomer failing to cure on occasions, because the armature (Fig. 2) has a tapered slot and slot wedges are used in place of banding, so that there is less tendency for the elastomer to be displaced under pressure.

Under fault conditions, this kind of machine can overheat, and failures have occurred due to the solder melting in the commutator risers. No damage appears to have occurred to the silicone insulation under these conditions and a solder with a higher melting point is now used to prevent a recurrence of failure due to this cause.

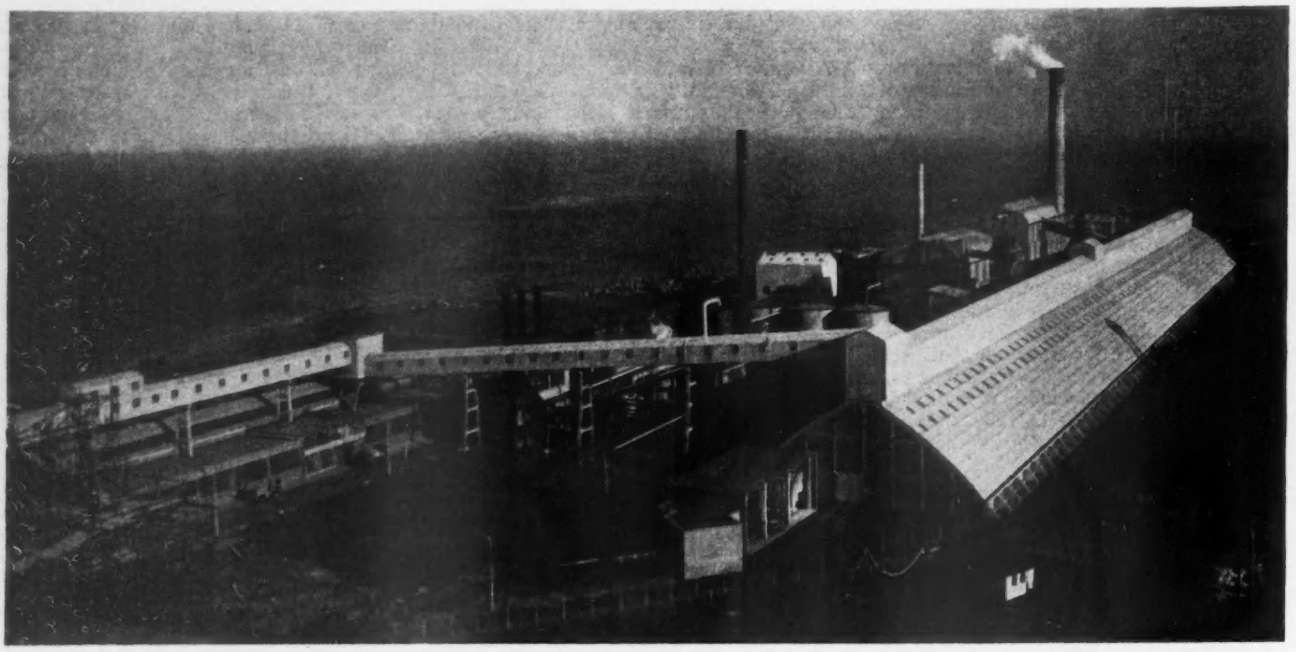
The " Metadyne " machine also incorporates an auxiliary machine, known as a regulator, which is used for speed control purposes. This machine is wire wound and under fault conditions this also may overheat. It is now the standard practice to rewind this machine with silicone materials, using glass-covered wire bonded with the silicone varnish. The earth insulation is silicone bonded glass mica and the complete coil is impregnated with a silicone varnish. The varnish used for impregnation is not a true silicone varnish but one modified by co-polymerisation with an alkyd resin. The modified silicone varnishes are valuable for many applications where resistance to oils and solvents and high bond strength are important. Although the maximum operating temperature for a modified silicone varnish is lower than that of a true silicone varnish, and they do not possess the advantage of leaving a non-carbonaceous residue on decomposition, they are useful when rewinding machines which have to endure intermittent overloading rather than sustained operation at elevated temperatures.

London Transport has had some ten years' experience in the use of silicone insulating materials for traction motors and is now proposing to specify their use on a fair proportion of traction motors being provided for new rolling stock. Their use is already specified for insulation when rewinding " Metadyne " machines.

Silicone materials are more expensive than the analogous organic compounds but it is not possible to generalise about costs for all kinds of machine. In the case of the " LT.100 " machine, the additional cost of insulating the armature with silicone materials is less than 5 per cent of the total cost of rewinding the machine, and this increase in cost can be justified if improved armature life can be obtained. The more stable chemical structure of the silicones and the absence of conducting products in the event of decomposition, suggest that thermal ageing will be retarded with these materials. Laboratory and accelerated tests, in fact, indicate that silicones show greater freedom from ageing than organic materials, but none of these tests can reproduce exactly the conditions encountered in a traction motor. The proof of these materials must therefore be under service conditions over a longer period than has so far been available for trials.

Because silicones are suitable for work at an elevated temperature, advantage can be taken of this property to reduce the size of a machine for a given output. This is useful in traction applications where weight and size are important, and the smaller machine should also be cheaper in first cost. The traction motor designer may be tempted to use the new rating to the limit, while the user of the machine would prefer to see some of the potential up-rating absorbed in improving the slot space factor, and therefore reliability, at the expense of a larger machine. The conflict between these points of view may be resolved in a compromise ; possibly in the form of a totally enclosed machine the same size as the existing ventilated machines.

Class " B " insulation for traction motors has until now relied almost exclusively on mica, but the tests show that the silicone elastomers can provide a practicable alternative to the orthodox forms of mica-based insulation. Extension and prolongation of these tests is still necessary, in order to confirm that improved performance and economy in maintenance can be achieved by the use of flexible insulating materials in place of mica.



Fertiliser works showing the main storage building to the right and the conveyor system from the docks

Fertiliser Works at Leith

Scottish Agricultural Industries, Ltd., has been engaged since the war in carrying out a series of modernisation schemes to anticipate the needs of the farming community, to improve quality and to reduce production costs. To manufacture a more concentrated product a new plant has been built on land reclaimed by the Leith Dock Commission and has been designed for an annual production of 150,000 *tons.*

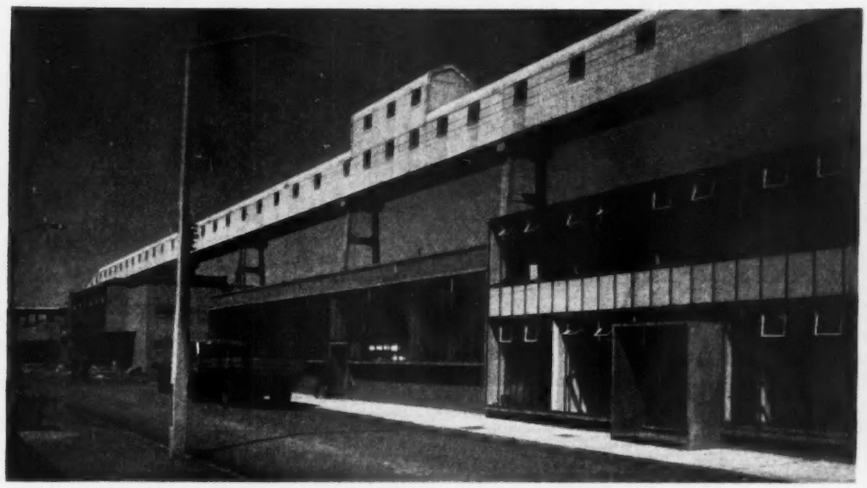
IN the years after the first world war the competitive strength of foreign suppliers brought economic pressure to bear upon a small number of long-established Scottish fertiliser manufacturing firms. This pressure resulted in their amalgamation, in 1928, to form Scottish Agricultural Industries, Ltd., so that some measure of rationalisation was possible to improve the competitive position. Nearly all the members of the group used small lead chamber plants to produce sulphuric acid, which was mixed with ground phosphate rock to form superphosphate, this being mixed afterwards with sulphate of ammonia, potash salts and other plant foods. August to December was the period for these operations and in the spring the powder fertiliser, which had set during the months in bulk storage, was broken up, milled and then bagged ready for delivery.

During the second world war, increased demands for fertilisers called for much higher production levels, so that eventually it was necessary to embark on a modernisation scheme which embodied the mechanical handling of materials at various stages of production to offset the shortage of labour. Furthermore, greater production called for, under existing manufacturing methods, larger maturing storage space and expanded milling and bagging capacity, and so stimulated the development of the granulation process. In this method, the materials are mixed, moistened and rolled to produce discrete particles which are dried, cooled and screened to give a product of 1mm to 3½mm size, which is easier to handle and less dusty, and which, when properly dried, was free flowing. Modernisation only proved a partial solution to the fertiliser production problem, since the various developments revealed the deficiencies inherent in the equipment and methods of the existing small plants. Thus, it gradually became evident that to increase production economically it was necessary to reconstruct completely the factories in order to convert them into efficient units. However, limitation of existing sites resolved the reconstruction problem into that of building an entirely new factory. This, apart from the question of finding a suitable site, also involved due consideration being given to the product itself, since current tendencies favoured increased concentration made possible by the manufacture of triple superphosphate or of ammonium phosphate. The latter was chosen, after a study of relative costs, as the basis upon which the factory processes would be designed. As planned, the scheme provided for five stages from raw material to finished product, namely, raw material handling and storage, production of sulphuric and phosphoric acids, manufacture of ammonium phosphate and the concentrated complete fertiliser, and the storage and despatch of the product.

The search for a site for the new factory ended with the decision to take over some 19 acres of land which was in the course of being reclaimed by the Leith Dock Commission. Extensive railway sidings are nearby, as is also No. 7 Berth, Imperial Dock, where ships up to 10,500 tons can be unloaded. Both these points, together with an efficient handling system, are of paramount importance since about three-quarters of the raw materials used have to be imported. The first pile was driven in October, 1954, and production was started in August, 1957, while sulphuric acid was produced by 1956. Sea-borne supplies of phosphate rock, sulphur, muriate of potash and sulphate of ammonia are transferred from the ships' holds by grabs, and the Leith Dock Commission are engaged in the mounting of new cranes of higher rating so as to raise dockside capacity to a maximum of 500 tons per hour. The grabs dump the material into movable hoppers from which screw conveyors discharge it through a chute on to an underground conveyor built below the floor of the dock shed and so as not to interfere with the handling of other cargoes. This first section of the conveyor system transfers to a second which has a length of 771ft and incorporates a Blake Denison belt weigher: it rises to a second transfer point where the third of the series of conveyors, set at right angles, delivers the material to one end of the main storage building. Here a fourth conveyor in the roof extends over about half the length of the building, delivering to a reversible shuttle conveyor having a length of 431ft and able to feed to any section of the main storage. The conveyors are carried in enclosed overhead gantries of welded tubular steel construction and clad in asbestos sheeting. The intake conveyor belting is 36in wide and travels at 250ft per minute, and the whole has a capacity of 350 tons per hour, based on material weighing 90 lb per cubic foot. Part of the overhead conveyor system and the office buildings can be seen in our illustration. For handling rail traffic there is a wagon tippler supplied by Henry Lees and Co., Ltd., which can handle wagons of 35 tons gross at 350 tons per hour: the material is passed via an apron feeder to a concrete cased elevator, with the hoisting machinery mounted on top, and thence by a cross conveyor to the shuttle conveyor in the store. It is of interest to note that a dock locomotive shunts the railway wagons into the factory and after that point the railway lines are laid at an inclination of approximately 1 : 230, so that the wagons travel under gravity.

Storage Building

The main storage building measures 900ft in length by 100ft wide and 60ft high to the



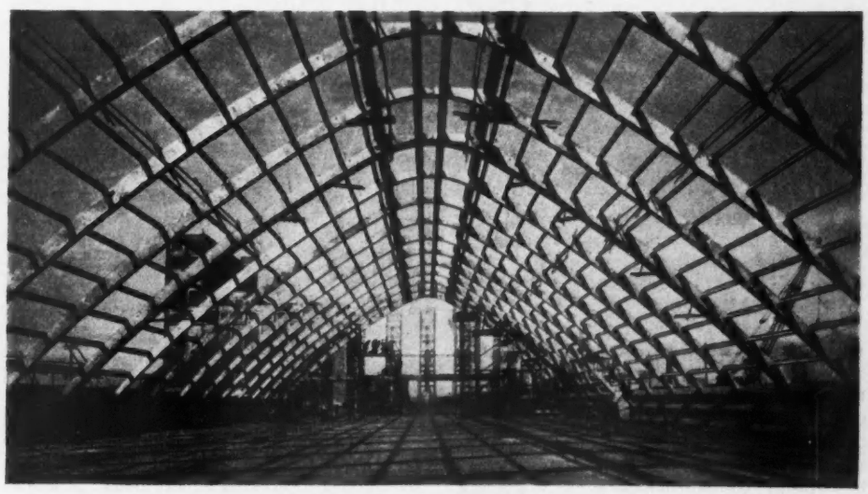
Intake conveyor gantry passing over offices and maintenance block

top of the conveyor gantry, and has a total capacity of 56,000 tons. Portable " Stelcon " precast concrete sections form divisional bulkheads to accommodate the various materials and prevent contamination. The concrete walls are 6ft high: one is carried on the old sea wall, while the other is carried on two rows of Franki piles which are driven to an average depth of 30ft through the fill and sand into hard clay, and are conservatively loaded. At intervals of 15ft there are external buttresses, carried on capping pieces, which take the thrust of the roof structure. This is of three-pin arch design and consists of two precast concrete arches, each about 75ft long and weighing about 6·5 tons. Strips of " Balata " belting are interposed at the joints to take up any high points. At every tenth bay there is a double arch and the precast and pretensioned " T " shaped purlins are sited at 4ft 6in centres; erection was by travelling crane and a travelling Jumbo of steel scaffolding. Our illustration shows the building in course of erection. The gable ends are infilled with reinforced concrete and brick panels. The building is clad with corrugated asbestos cement sheeting. There is no piling under the concrete floor, which is laid between prestressed beams arranged between each buttress, the tensioning wires being anchored in the external buttresses. The beam is flexible and is designed to deflect with any settlement of the floor. On the top of the arch are four reinforced concrete crown beams; the middle pair carry a timber walkway on one side of which is the reversible shuttle conveyor, while the space on the other side of the walkway is available for a second conveyor. Portable timber covers over steel grids permit the shuttle conveyor to discharge at any point along the length of the building. In each section of the building there is a recovery pit into which the raw material is pushed and then raised by an elevator in a concrete shaft to a cross conveyor which delivers to the process building.

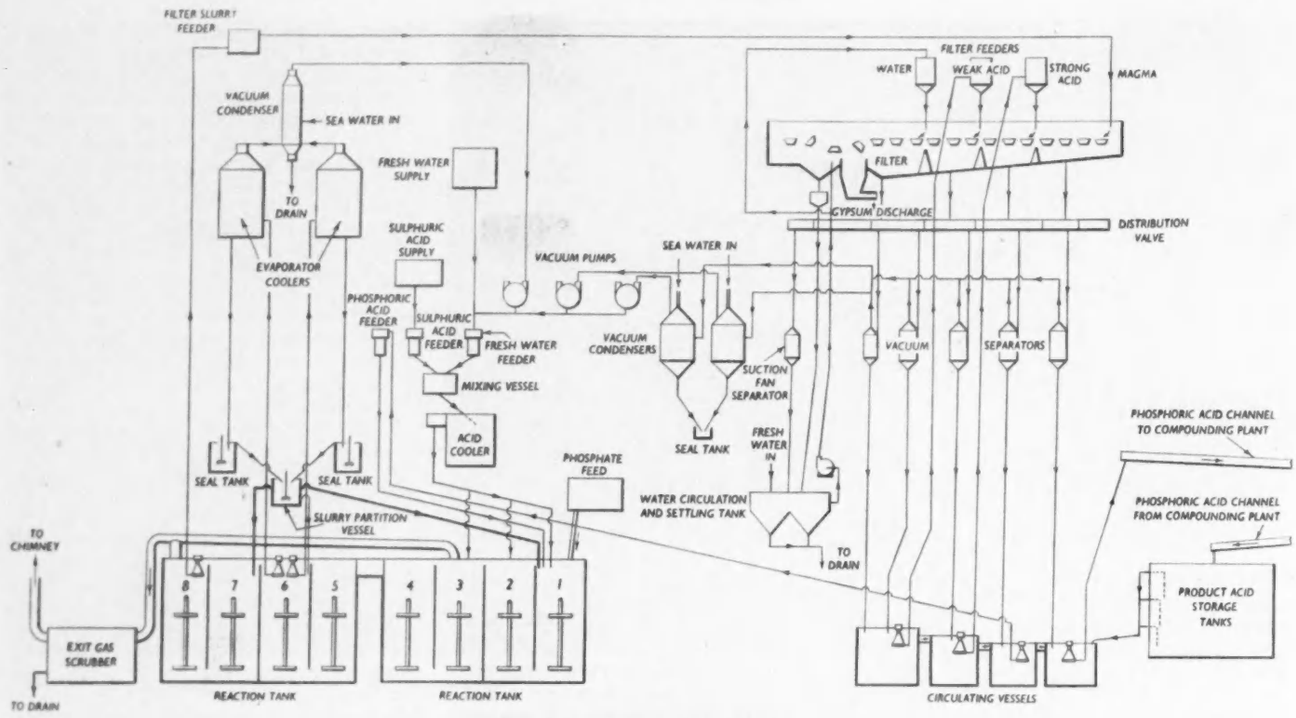
Process Plants

Despite doubts about elemental sulphur supplies, a sulphur burning contact plant for the production of sulphuric acid was installed since this method offered a considerable cost advantage. However, as an insurance against any shortage of sulphur, space has been left, and the plant so designed, that conversion to pyrites burning can be effected. The actual unit is a Monsanto contact plant designed and constructed by Simon-Carves, Ltd., and able to produce 175 tons of sulphuric acid per day. From the storage building the sulphur is delivered to a brick-lined underground pit, measuring 47ft by 22ft by 6ft, where it is melted, overflows into a tank and is pumped through a Kelly pressure filter, which removes ash and some of the bitumen present, to a clean tank. From here speed-controlled Holden and Brooke pumps transfer the molten sulphur through a steam-jacketed pipeline to a burner where it is burned in a vertical cascade burner in a preheated air stream to sulphur dioxide of about 7·5 per cent concentration. The combustion air is dried by passing through a tower packed with ceramic rings irrigated with 94 per cent sulphuric acid, while the gases from the burner pass through a waste boiler and are reduced from 980 deg. to 400 deg. Cent. Steam is generated at 17,500 lb per hour in the boiler at 360 lb per square inch and 660 deg. Fah., and drives the turbo-blower, consisting of a Keith Blackman fan driven through a 10 : 1 reduction gear by a Greenwood and Batley De Laval turbine of 275 h.p., which drives the gases through the plant. There is also a 300kW turbo-generator, and the low-pressure exhaust steam from both units provides factory heating and is available for process purposes. Suspended matter in the gases is removed in a quartz filled filter and the sulphur dioxide is converted to sulphur trioxide in a convertor having four catalyst beds. In the first stage the action is exothermal and the gas is raised in temperature from 425 deg. to 600 deg. Cent. and is subsequently cooled in a heat exchanger. After the second stage the addition of quench air cools the gases further and the mixture is fed to the third stage where most of the conversion occurs. The gases pass over the boiler superheater elements before entering the fourth pass and then leave the convertor at about 410 deg. Cent. into a boiler feed water economiser and thence through a tube and shell heat exchanger where the temperature is reduced to 180/200 deg. Cent. for absorption which takes place in a tower packed with ceramic rings over which flows 98·5 per cent sulphuric acid. This acid passes through Newton Chambers salt water circulated needle tube cast iron coolers. The sulphuric acid is handled in cast iron pipes and storage is provided for 3900 tons in three mild steel tanks. Controls are located mainly in a central room where there is a variable-speed control for the sulphur pumps for adjustment of feed to the burner.

The phosphoric acid plant is housed in a clad reinforced concrete framed building, having piled foundations measuring 112ft by 64ft by 53ft to the eaves, having a suspended floor to carry the Prayon filter for which two concentric circular walls are provided. On the floors are " Nori " acid-resisting tiles laid in rubber latex cement with Alkathene placed between tiles and floor. Roof trusses are of steel and the reinforced concrete chimney, 120ft high by 4ft internal diameter, is lined with acid-resisting bricks. Phosphoric acid is manufactured by the wet process, of which we include a flow diagram, involving the reaction between sulphuric acid and phosphate rock to give phosphoric acid and calcium sulphate, the latter being removed by filtration as gypsum. The Prayon plant employed was designed by the Engineering and Industrial Corporation of Luxembourg and consists of two reaction vessels, each divided into four compartments, lined with rubber and carbon brick, the hot magma containing sulphuric acid, phosphoric acid and traces of hydrofluoric acid being very corrosive. From the raw material store, the phosphate rock passes through a crusher and then at a controlled rate of flow via a weigh belt feeder to an air swept Bradley Poitte mill. In addition to the phosphate, sulphuric acid, dilution water and weak phosphoric acid are piped to the reaction vessels where the reaction takes place mainly in the first half of the system, while the second part ages the magma and produces



Main storage building, showing form of construction



Flow diagram for phosphoric acid plant

gypsum slurry. The magma is recycled from the sixth compartment to the first through two evaporator coolers, which provide temperature control, while from the last compartment a proportion is pumped to the eighteen-cell Prayon filter. This consists of a number of trays in a horizontally rotating annular ring such that the stainless steel trays, having synthetic fibre filter cloths laid on a perforated rubber base, are brought successively into position for the washing and filtration operations. These consist of filling the tray with magma and the filtering off of the strong phosphoric acid, under vacuum, to storage tanks, followed by three washings of the cake under vacuum. The wash liquors are recycled and that from the first wash, acid containing 26 per cent phosphorous pentoxide, is recycled to the reaction system. After the third or water wash, the tray is tipped over to remove the cake of gypsum which falls into a disposal mixer screw, where it is slurried with sea water and fed to drain. The process is fully instrumented and a control room provided.

Dorr-Oliver Inc. of Stamford, U.S.A., designed and Simon-Carves, Ltd., engineered the granulation plant, of which we reproduce a flow line diagram, and which is housed in a steel-framed building having floors of reinforced concrete, acid proofed as required, and a 200ft high reinforced concrete chimney tapering in diameter from about 17ft to a little over 13ft in diameter. The process involves the neutralising of phosphoric acid by ammonia gas and the resulting slurry is added to sulphate of ammonia and muriate of potash in the proportions prescribed. Salts are added to the ammonium phosphate slurry and the granules, formed in a plunger, are dried and screened.

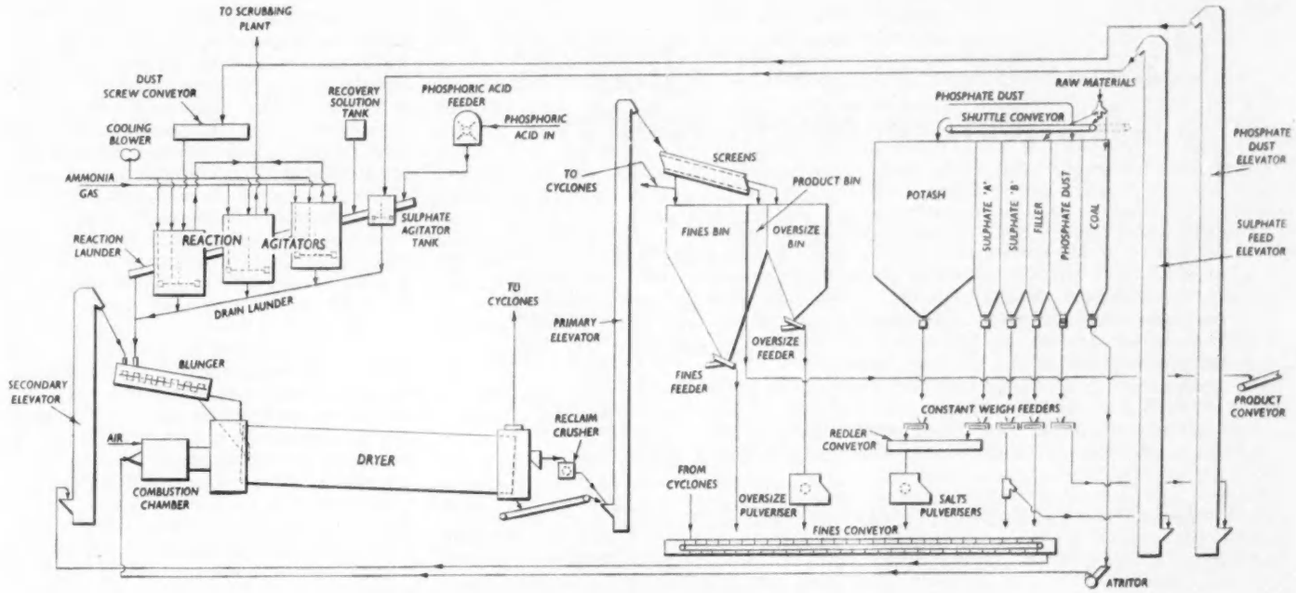
The strength of the phosphoric acid has to be raised from 30/32 per cent to 31/37 per cent phosphorous pentoxide, and for this purpose a single effect vacuum evaporator designed by the Svenson Evaporator Company, U.S.A., is used. The acid is pumped through at relatively high circulation rates, to avoid the formation of deposits of gypsum and fluo-silicates, and the evaporated acid is discharged through a sealed barometric leg to an agitator tank. All tanks holding phosphoric acid are of steel and rubber lined. Evaporator temperature regulates the strength of the acid. Coppee Company, Ltd., supplied the ammonia distillation plant, designed to work automatically, and there are two synthetic ammonia stills of bubble cap tray pattern. The ammonia is stored in special tanks which have been constructed by Preload, Ltd. The tanks have a piled floor and the walls are of ordinary concrete having wires in vertical ducts. After the roof is fitted, a carriage carrying a wire die and suspended from wheels which follow a circumferential track on the roof wraps wire around the outer surface of the wall. The spacing of the wire increases gradually from the base towards the top and the correct tension is given to the wire by it being passed through a reducing die. When the wiring is completed the exterior of the tank is gunited. The ammonia gas neutralises the phosphoric acid in four reaction vessels, the reaction being highly exothermic so that part of the water, coming as part of the phosphoric acid, is evaporated and vented to scrubbers. At this point the slurry consists of ammonium phosphate and ammonium sulphate, containing nitrogen and phosphate to which is added sulphate of ammonia, and muriate of potash. To reduce the moisture level of the slurry it is necessary to carry a recirculation load of dry material which consists of crushed oversize and fines from the screening stage. The slurry meets the salts and dry solids in a blunger, which is a twin shaft trough mixer producing granules having a 5 per cent moisture content.

The granules pass through a rotary drier, supplied by Ernest Newell, Ltd., which is 93ft long by 11ft diameter and fitted with internal flights and preceded by an inlet scroll section. A single-stage Musgrave high-efficiency fan supplies air at about 40,000 to 50,000 cubic feet per minute and heating is by pulverised fuel produced in equipment manufactured by Alfred Herbert, Ltd. In the screening section, after the drier, the material is divided into oversize, product and fines, the screen sizes being 3mm and 1·5mm respectively. The oversize stream passes through a cracker and returns with the fines to the blunger, as already mentioned. The salts which are added are fed to process through Richard Simon constant weigh feeders controlled by Heenatron electronic controllers and are ground to size by Henry Simon "Entoleter" mills. The gaseous effluent rising from the drier is purified in two-stage Doyle scrubbers of 75,000 cubic feet per minute capacity. Liquor from the fresh water stage is returned to the plant, while the sea water from the second stage is discharged to the sea and the washed gas discharged to atmosphere.

Product Storage

A belt conveyor carries the product to the main storage building where a buffer supply of 2000 tons is held or to hoppers which are used for filling road or rail vehicles. Normally, Covhop rail wagons will transfer the material to the storage and packing plants, which are being built on the site of the old works. The bulk storage building, illustrated herewith, has a capacity of 40,000 tons and measures approximately 355ft by 160ft by 48ft 3in to the eaves, and is divided into thirteen storage bays. It is of reinforced concrete with steel roof trusses and the outer walls are carried on timber piles. There is a double central division surmounted at intervals by concrete standards carrying a cross beam and the storage depth available is 30ft. Below the central divisional walls is a tunnel sited below ground level.

Railway wagons deliver the product to hoppers from which cross conveyors supply a rising conveyor which, in turn, transfers to twin cross conveyors at roof level, and these feed the two shuttle conveyors which deliver the product to the various storage bays at 100 tons per hour. Recovery of the product is by electrically powered bulldozers, which are moved from bay to bay by overhead hoist, carried by the central cross beams, which push the material through the ports in the central wall. These ports are uncovered and the product drops down chutes on to an underground belt conveyor and is delivered to a pit where a series of



Flow diagram for compounding plant

conveyors raises it to the top of the screening house. Here the product drops to ground level and is transferred by conveyors to concrete hoppers over the bagging plant, at 230 tons per hour. In this plant are Simon automatic weighers and the product is packed into paper sacks by valve bagging units, each capable of handling 45 tons per hour.

Services

Large quantities of water are required for cooling and gas washing purposes, and to meet the demand provision has been made to draw the necessary supplies from the Imperial Dock. A reinforced screening chamber shaped to fit into a corner of the dock has been installed and also a pumping station having two Harland " Uniglide " centrifugal pumps, one being a standby. The station can handle a maximum of 180,000 gallons of sea water per hour, the water being drawn into the chamber through two coarse screens and then through duplicated fine screens, and being delivered to the works through a 24in diameter cast iron main. For fresh water there is a 10in diameter main with a capacity of 16,000 gallons per hour, and a 6in diameter main for gas supplies. Effluent is carried away in an outfall drain which is built in 40ft long sections of reinforced concrete, and designed as a beam, carried on two rows of piles. There is a lining of " Nori " tiles laid on Alkathene sheet and the drain has reinforced concrete slab covers. The concrete section of the drain extends to the edge of the fill and is then continued as a 21in diameter cast iron pipe carried on twin lines of greenheart piles, there being provision made for two pipes.

In addition to the waste heat boiler in the sulphuric acid plant there are three Cochran boilers housed in a building having no internal bracing or floors. The boilers, fitted with Laidlaw Drew oil-firing equipment, have a total capacity of 22,500 lb of steam per hour at 150 lb per square inch, and are arranged to act as steam accumulators when not being fired. Two Broom and Wade compressors provide 400 cubic feet of air per minute at 100 lb per square inch for general purposes, and another compressor of 20 cubic feet per minute capacity at 50 lb per square inch maintains the instrument air supply, for which a Birlec air drier is installed. Electricity supplies are taken from the South of Scotland Electricity Board at 6600V and within the plant a high-tension ring main feeds three substations having a total capacity of 3500kVA. For use in the process buildings one 1500kVA and two 1000kVA Bruce Peebles transformers reduce the voltage to 415V. A. Reyrolle and Co., Ltd., provided the oil circuit breakers for the h.t. switchgear, and M. and C. Switchgear, Ltd., supplied the oil circuit breakers for the l.t. switchgear.

In addition to the small laboratories found in each process block there is a central control laboratory and for maintenance of the plant there is a well-equipped workshop and stores.

Messrs. Kinnear and Gordon, Edinburgh, were the civil engineers for the project, and Basil Spence and Partners were the architects, while Ian Hunter and Partners, Edinburgh, were responsible for the heating and ventilation.

Other Main Suppliers

Barry, Henry and Cook, Ltd., Spencer (Melksham), Ltd., handling plant ; English Electric Company, Ltd., Bruce Peebles and Co., Ltd., electric motors ; Redpath Brown and Co., Ltd., structural steelwork ; Incandescent Heat Company, Ltd., phosphoric acid evaporator ; Kottler and Heron, Ltd., concrete storage tanks ; Munro and Miller, Ltd., tubular steel gantries ; Prodorite, Ltd., acid-resisting tiling ; Sack Fillers, Ltd., bag packing machines ; South Durham Steel and Iron Company, Ltd., Bone, Connell and Baxters, Ltd., tanks ; Spencer and Halstead, Ltd., Visco Engineering Company, Ltd., dust-collecting equipment ; Tileman and Co., Ltd., concrete chimneys ; Pyrotenax, Ltd., British Insulated Callender's Cables, Ltd., cables.

Fertiliser bulk store of 40,000 tons capacity

Book of Reference

The Structural Engineers' Data Book. By D. A. Creswell, A.M.I.Struct.E., and J. H. G. King, A.M.I.C.E. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 35s.—Basic theory in several branches of structural design, in the form of concise notes, together with design data, are presented in this loose-leaf book which is intended as a handbook for the structural designer, for reference and not as a text-book. More specialised subjects—plastic theory, shell roof designs, &c.—are excluded since it is intended that the book should have a general appeal to structural engineers ; the loose-leaf arrangement allows personal notes or up-to-date information on such subjects as codes of practice to be added. The subjects dealt with are as follows : theory of structures ; reinforced concrete design ; structural steelwork ; timber ; structural brickwork and masonry ; soil mechanics ; loadings, British standards and materials ; mathematical tables and miscellaneous data ; and surveying. A great deal of information is compressed into each of these sections.

Conference on Technology of Engineering Manufacture

No. I

Some sixty papers were presented for discussion at the Conference on Technology of Engineering Manufacture, which was arranged by the Institution of Mechanical Engineers and held from March 25 to 27 last. Two sessions of the conference dealing with the forming of materials were under the chairmanship of Dr. D. F. Galloway and the Earl of Halsbury, respectively. Two further sessions on the subject of machining of materials were under the chairmanship of Sir William Stanier and Mr. L. H. Leedham. One session, dealing with inspection techniques, was under the chairmanship of Dr. F. H. Rolt. The introductory notes of the reporters at the sessions provide an excellent guide to the scope of the papers presented, and we reproduce some of these notes dealing with the sessions on the forming of materials.

IN introducing the eleven papers presented at the first session of the Conference on Technology of Engineering Manufacture, held at the Institution of Mechanical Engineers on March 25, Mr. W. C. F. Hessenberg, the reporter, said that he did not propose to follow the order in which the papers appeared, but had grouped them into two papers on casting, some on joining, some on formation, and a solitary paper on coating.

He said: Dealing first with the paper by Dr. H. H. Scholefield and his colleagues (" Investment Casting, Using the Mercury Pattern Method ") in their introduction they give a very useful kind of " family tree " setting out most of the well-known investment casting processes. They devote the major part of the paper to a discussion of the " Mercast " process, which is an investment casting technique using mercury as the disposable pattern material. The investment mould itself is a zircon-base ceramic fired at a high temperature " to render it rigid, stable and inert to most alloys." On the same page they give tolerance figures for these castings, and one wonders how it is that no distortion is caused when these moulds are fired green at high temperature.

The authors then discuss the question of casting design and the advantages which castings have over parts machined from the solid, moulds and mould design, tooling and some typical castings. An extremely interesting part of the paper deals with booking moulds, in which two mercury patterns can be cast side by side, but separate, and afterwards pressed together to form a single die. This is a form of pressure welding made possible by the fact that the mercury is at a high temperature or near its melting point. The authors discuss the potentialities of this process in relation to various applications such as gas turbine blades, and end with a discussion of the advantages of castings as compared with wrought material for this purpose.

The other paper on casting, by Mr. J. S. Turnbull (" Precision Sand Casting "), begins also with a general review of casting processes. A statement which may evoke some comment is that the lower the tensile strength the better the castability ! The author discusses precision casting processes and then comes to the main theme of his paper, which is investment casting, and particularly the " Alphax " process, developed in his own works. He makes two important points in this connection. First, he says : " It is disappointing to record that the impact of investment casting on the sand foundry has been extremely small . . . due largely to the fact that sand foundries are too busy producing castings for which there is considerable demand and tend to turn their development skill to solving the immediate problems rather than future ones." The other point is that for steel the right approach is to combine steel founding practice (the melting of the steel in direct-arc furnaces) with the best features of the investment foundry. This is what he calls the " Alphax " process, and he deals with this in some detail.

Perhaps the most interesting paper of all is by Mr. E. V. Beatson (" Brazing in Light Engineering "). He begins by making a valuable and impartial survey not only of brazing, but of all the processes which compete with brazing. He discusses some of the newer brazing alloys to deal with materials such as stainless steel and Nimonics, and deals interestingly with the degree of concentration of oxygen to which it is necessary to keep down in order to braze stainless steel. He refers to the new nickel-chromium-boron type of alloy now coming into use, and makes interesting mention of a process known as " Cone-Arc," which is used for welding tubes into tube plates, in which the arc is apparently struck between the tube and the torch and without moving the torch the arc is made to go round the edge of the tubes by itself at high speed.

The author then deals with high-frequency induction brazing and indicates that fluxes, or at least chloride-containing fluxes, are on their way out, which can well be understood owing to the corrosion troubles to which they are likely to give rise, and that hydrogen and vacuum are taking the place of fluxes.

Welding

Mr. Hessenberg continued: I come now to the group of papers which deal with welding, and I shall begin with that by Dr. Gross (" Modern Developments in Arc Welding "). In Part I of the paper he says, first of all, that manual welding is still used for over 90 per cent of all arc-welded steel applications, and he goes on to discuss new types of electrode developed for manual welding, and in particular the iron powder rutile type, which gives the advantages of low-hydrogen weld metal and very high rate of deposition. He then deals briefly with the question of power sources, and I have some difficulty in reconciling his statement that in this country 75 per cent of all arc-welding applications are a.c., but that some Continental countries, perhaps for lack of the safety device used here, do not use a.c. to the same extent, with the statement in the next paragraph that there are considerable advantages in d.c. power sources. It seems to me that we may be going the wrong way, and that Continental countries are going the wrong way more slowly.

He gives a very useful table of the maximum deposition rates of the principal arc-welding processes and then discusses the submerged-arc process, the gas-shielded bare-wire process, and new processes employing flux and gas shielding in combination.

The paper by Mr. C. A. Burton (" Modern Developments in Resistance Welding ") contains some very interesting information with regard to developments in resistance welding in this country and abroad. He begins with the statement that we are lagging behind the U.S.A. in this development and that there may be good reason for this, because the need for the development of resistance welding has become more urgent there, but later he talks about spot welding in rolling stock and the fabrication of structural beams, the development of which has largely taken place abroad. I mention those points because in a conference such as this it is appropriate to discuss whether we are taking the lead in these matters or lagging behind, and no one should feel inhibited in talking about a subject of that kind.

The most interesting example which the author gives concerns wheel manufacture, and he gives a list of the various processes which are carried out automatically on wheels, including automatic rechecking of the quality of the weld. He then deals with resistance welding in the aircraft industry and mentions that an aircraft may have 1,000,000 to 1,500,000 spot welds in it. In descriptions of spot welding in structural engineering, particular reference is made to a power station in France. He refers to the strength of these spot-welded fabrications, stating that it is 80–90 per cent of that of the parent metal. One would like to know whether that applies only to static strength or whether the fatigue strength and creep are equally good in relation to the solid metal, and also whether or not the plastic collapse method of design, which has become popular, is applicable to fabricated constructions.

A similar paper by Mr. R. M. Watts, deals with fabrication practice for machine elements. This is probably the application of welding in its largest form at the moment in terms of size. The author gives a list of the things which can be made by fabrication rather than by casting or other processes. The advantages of fabrication as compared with cast iron are discussed, but not very much in relation to cost. It must be borne in mind that one starts with a more costly raw material in fabrication than in casting.

Materials Forming

I now come to the " forming " group of papers, beginning with that by Mr. R. Tilsley and Mr. F. Howard (" Recent Investigations into the Blanking and Piercing of Sheet Materials "). In their introduction they say that " little is yet known of the mechanism of plastic flow and fracture in the blanking or piercing operation." They deal with the clearance between punch and die and give interesting figures showing the relationship between blanking force and clearance between the punch and die and stripping force and clearance. The various metals seem to behave similarly with regard to stripping force but differently with regard to blanking force, and one wonders whether it is because in the first instance the authors have chosen the U.T.S. to express the ratio of blanking force, instead of the yield ; otherwise, I think that they might all have come together. The most interesting part of the paper is the

section on finish blanking, where by means of acute observation of what was done in the watch-making industry and by empirical research work they have devised the process of finish blanking which is a considerable boon to those who have to use the blanks.

In introducing their paper, "Thread and Form Rolling," Mr. D. H. Seymour and Mr. F. M. Lomas make a statement which may be challenged, that "rolled threads are in general more reliable than machined threads." They then deal with the question of the forces developed in the process, giving figures and graphs relating to different metals.

The determination of blank diameter is another useful piece of work which has been done, because it has removed the element of trial and error from what is quite an intricate process. They discuss the effect of roll diameter, and in dealing with applications of thread rolling, refer to the process in which a washer is automatically fed on to the shank of the screw. In an interesting description of planetary thread-rolling machines, they mention the astonishingly high rate of production by the introduction of this type of machine, which is put at 38,000 components per hour. Finally, in some well-written conclusions, the authors set out in detail seven advantages and six disadvantages of the thread rolling process.

The paper by Mr. R. A. Paulton and Mr. B. N. Colding ("Two New Industrial Processes for Plastic Deformation of Metals") deals with the "Hydroform" and the "Hydrospin" processes. The "Hydroform" process is very loosely described in figures and the authors make the important point that, since there is no close fit between the punch and the female die, close tolerance is unnecessary. Thick or thin stock will form equally well. They add: "This fact also eliminates costly die failures, when two or more blanks are accidentally formed together." They say, rather surprisingly, that the lubricant is applied to the blank on the side which is facing downwards, and not on the side in contact with the rubber. It may seem surprising that the rubber is not dragged along by the blank as it is drawn in and torn away at the sides, but evidently that does not happen. They give a lengthy analysis of the mechanics of this process, largely concerned with the fact that the wall thickness remains constant, when it would not do so in the ordinary deep drawing process.

In dealing with the "Hydrospinning" or "shear spinning" process, they bring out very clearly the difference between ordinary spinning and shear spinning—in ordinary spinning the blank keeps its area, but the width of the finished article is considerably less than the diameter of the blank, whereas in shear spinning the diameter of the finished article is the same as that of the blank. In their conclusions they list a number of advantages, and I would draw attention to three of these. They say: "The physical properties of the material are improved. The hardness increases directly as the percentage of reduction of wall thickness." That surprised me. They also say: "Parts with varying wall thickness may easily be spun since the rollers are tracer controlled."

Finally, they say: "Grain structure of the part spun is greatly improved, making the process extremely useful when forming parts subject to shock loads, such as truck wheels." I think many will agree that the same is true of the deep drawing process.

The paper by Dr. F. W. Salt and Mr. S. S. Carlisle ("Metal Coating and Corrosion Prevention with Special Reference to Sheet Steel") is very important. They deal first with the mechanism of corrosion and then go on to discuss particular remedies. They refer first to plating, hot dipping and spraying, and then discuss zinc and zinc-alloy coatings and the electrolytic protection which zinc gives. They go on to refer to aluminium coatings and the methods of putting them on, and mention the cold rolling of the steel strip to get a better finish and improve the ductility of the aluminium coatings, and the difficulty of annealing the steel strip after that has been done. Has flash annealing been considered for that purpose, and will the kinematics of the annealing rate and alloy growth rate have been compared to make that possible?

The authors then turn to tin and tin-alloy coatings and mention the use not only of tin, but of tin in conjunction with lacquer. They discuss nickel coatings and describe an interesting American process which is a substitute for stainless steel, mild steel being heavily plated with nickel to give a material with the same external properties of corrosion resistance as stainless steel. The second half of the paper deals with organic coatings—paints, varnishes, resin claddings and dispersions, and lacquers.

In opening the second session on the forming of materials, the reporter, Professor H. Ford, said: The papers for this session, judged by their titles, would seem to have little in common, but a closer study of their substance shows a number of fundamental connections between most of them. The metal-forming processes depend for their results upon two basic factors. The first is the development of such stress difference within the material to be formed that the necessary complex of shear stress can arise so that permanent distortion takes place. The second is the superposition of a hydrostatic compressive stress—that is, a stress which is uniform in all directions of such value that excessive tensile stress and, hence, fracture, is suppressed.

Metal-forming processes differ then in the distribution of the shear stresses needed throughout the plastic mass to cause the metal to flow where it is wanted and in the intensity of the uniform compressive stress required to prevent cracking and fracture, depending therefore upon the form and dimensions of the raw material and of the component it is desired to make, so different forming processes will be more or less effective and efficient.

Since compressive stresses cannot be applied without some form of contact between the material and the rigid boundary, frictional forces arise at these boundaries which also modify the efficiency of the process or, at worst, may impose severe limitations on the field of usefulness of that particular process. Viewed against this background, such processes as indenting, extrusion, forging or upsetting are not so dissimilar as they would appear to be when considered entirely from the practical aspect.

The paper by Mr. A. Throp ("Indenting and Embossing") describes some aspects of the indenting and embossing of metals and shows some of the advantages to be gained over hand-stamping and electrical etching in a number of cases. Schemes for both increased output and reduced costs are amplified and the possibilities of automatic machines are discussed. The loads required for indenting various metals with characters to different depths are given. Indenting involves the same kind of deformation as in the indentation hardness test, and indenting loads are proportional to the corresponding hardness number. The only exception is titanium 317. It would seem in general that these make up a rational method of predicting the indenting load.

The author considers that spark erosion or ultrasonic abrasion is unlikely to compete with pantograph engraving for making the dies. It would be interesting to have other views about this, because in some fields—for example, in the cutlery trade—the spark machine process has been found to show big economies in making and finishing dies.

Forging

Mr. H. D. Challen discusses a new method of producing precision hollow forgings in non-ferrous alloys. The innovation consists in using closed dies and confined radial flow as in normal forging with axial extrusion. Since the main forging operation is done within one of the dies, the amount of radial flow is limited and controlled, and the formation of a flash is suppressed. The crank press is used with these alloys in both straight closed-die forging and also multiple-core forging to be carried out by ancillary machines actuating punches or pegs which are close to the main press machine. Speeds of running are from forty to 100 strokes per minute and although the author states that the practical limit of wall thickness is $^{3}/_{32}$in, the inevitable conclusion is that some piercing and extrusion operations must involve strain rates of almost impact extrusion values. Examples of the rate of components which can be made are given, and it is claimed that dimensional accuracy of $\pm 0{\cdot}005$in can be held, this allowing for tool wear. Machining allowances are only required for closely mating surfaces.

Messrs. A. H. Waine and J. R. Rait ("Forging and Heat Resisting Metals") discuss the forging of heat-resisting metals. They state that whilst forging presses themselves have not undergone any major changes in basic design, much progress has been made in control and manipulation and in the performance of the presses, particularly as a result of research and development work in Great Britain during recent years. The main objective of all these developments has been increased efficiency in the form of more work per heat, and as a result of the reduction in the number of reheatings necessary, and accordingly an increase in output.

The question of the design of press tools as they affect the quality of the finished product has been studied by B.I.S.R.A. in recent years. The press-forging operation involves in most cases less lateral restraint than closed-die forging. Accordingly, the hydrostatic component stress is usually lower, so the tensile stresses rise at an earlier stage in the deformation, because the frictional forces are high. The authors point out the advantages of upsetting as a preliminary to the main forging operation. They also discuss the relative merits and demerits of press and hammer forging. They set out some considerations which limit the use of closed-die forging as against press forging, and explain that quite apart from any technical advantages, press forging has other advantages for small components.

The problems of heating for forging and the metallurgical consequences of forging processes are dealt with and the interesting possibilities of fabricating larger parts, such as large Nimonic ring forgings, by centrifugal casting, followed by becking out under a forging hammer, are referred to, as well as the vacuum melting and vacuum casting processes. These should result in alloys having much reduced hydrogen content and harmful non-metallic inclusions and dissolved gases.

(To be continued)

Developments at Scientific Glassware Factory

PRODUCTIVITY at the Stone, Staffs, works of Quickfit and Quartz, Ltd., scientific and industrial glassware manufacturers, is stated to have been increased in some cases from between four to six times by the introduction of new plant and the adoption of a new mechanised layout.

Conveyor System.—Laboratory glassware production is carried out in three main shops —joint forming, grinding and lamp working.

As a start to increasing output, an entirely new mechanised layout has just been installed in the joint-forming and grinding shops ; a conveyor system illustrated takes products directly off the machines (a battery of forty-eight lathes) for the next stages of production, i.e. inspection, annealing and grinding.

New Grinding Plant.—Most of the grinding is done on semi-automatic machines, which have been specially designed by the company's development department, and which are claimed to increase productivity between four and five times compared with the hand-grinding method, although this latter process is still used for small runs. Some of the machines are seen in the accompanying illustration.

With the semi-automatic method a very high standard of quality is said to be obtained, the conical joints having profiles accurate to within one ten-thousandth of an inch.

It may be of interest to note that the introduction of these high productivity machines has been effected without any substantial reduction in the labour force, as the higher output has enabled the company to exploit new markets, particularly overseas.

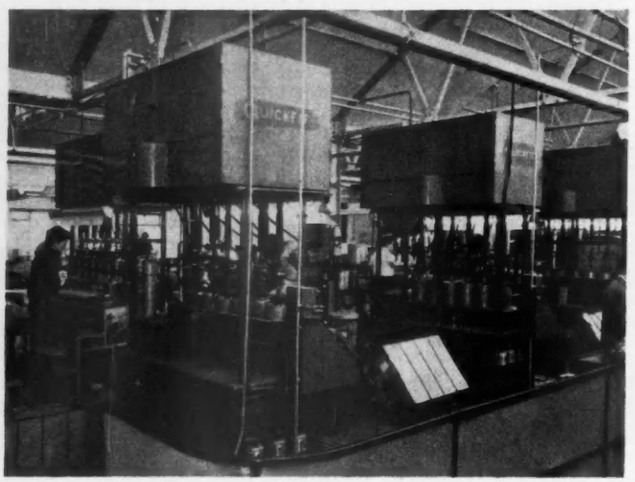
Annealing.—For some time, intermediate annealing had been carried out by heated cowls which could be dropped over and lifted off the glassware. This principle has now been applied to the final annealing of heavy wall ware which cannot be properly annealed in a continuous lehr. Working in conjunction with the Midlands Electricity Board and Shelley Electric Furnaces, Ltd., an electrically heated oven, 12ft by 6ft by 6ft and weighing 3 tons, has been designed which can be raised and lowered on a travelling hoist. Thus, while one batch of glass is being annealed another can be prepared. Immediately the first batch is finished the second can begin, giving a considerable increase in throughput and great saving of heat. This plant is seen in action in the illustration below.

Factory Processes.—Much of the equipment at Stone has been built to Quickfit and Quartz's own design, in most cases in their own workshops, and in the engineering companies of the Triplex Group, Stern and Bell, Ltd., and Weldall and Assembly, Ltd. The shaping lathes used in the production of ground glass joints and the very heavy lathes used for production of industrial plant are typical examples.

Production in the factory is divided into two main streams: laboratory glassware and chemical plant. The difference from the manufacturing point of view is that glass plant is made in much larger sizes, but smaller numbers, than glassware for the laboratory.

The raw materials are glass tubing and mouldings of comparatively simple shapes, but of many different sizes, which are joined together and reformed into the various units, many of which are very complicated. This work is carried out by lamp workers using, in most cases, lathes or specialised jigs. Where small quantities of light work are required—and a large amount of scientific glassware is of this nature—skilled bench-workers are much in evidence. Even in the chemical plant shop, where most of the product is too heavy for handwork, there is an important section of bench-workers bending and assembling the coils that are later built into heat exchangers. In this shop, the large oxy-coal gas flames needed to work the thick glass involved are supplemented by electric heating. Two-stage annealing is generally necessary with this heavy glassware.

In the joint-forming shops two automatic conveyors like the one shown can carry the work of four lines of bench workers to the inspection department



Some of the semi-automatic grinders with which, it is claimed, conical joints are finished faster and with much greater precision than hand-grinding permits

Electrically heated "Top-Hat" oven for annealing heavy-wall glassware

Institution of Naval Architects

ANNUAL SPRING MEETING

No. II—(*Continued from page 505, April 4*)

MR. J. M. Murray was in the chair when the meeting was continued on Wednesday morning, March 26, with the reading of paper No. 2, which was :

THE DESIGN, CONSTRUCTION, AND OPERATION OF A CLASS OF TWIN SCREW TUGS

By E. C. B. Corlett, M.A., Ph.D., J. Venus, C. H. Gibson.

Synopsis

The paper describes the various considerations involved in the design and construction of a particular class of tug and also operational experience with ships. Part I is concerned with design and operational requirements with special reference to stern gear and includes the dimensions and characteristics of the tug with notes upon the development of the lines, and the design of the propellers. Tables set forth the performance of the propellers. Details of construction are discussed in Part II of the paper while operational considerations are the subject of Part III, and touch upon performance in service, stability and safety, and machinery in service.

Discussion

Dr. Ir. J. D. Van Manen : The material published is of highly practical value, and it is hoped that it will stimulate other yards and shipowners to record their experiences in this field. Being engaged in the work of the Dutch ship model tank, I am interested in the correlation between the qualitative results of the manœuvring tests with models and the full scale ships.

The procedure described in this paper, of making tests with radio controlled models of the ships manœuvred by the pilots and tugmasters themselves, has led to a fine solution in this case. However, both the shipowners and the model tanks should try to find dimensionless qualification factors for the manœuvrability of ships. Perhaps the suggestions published by some Japanese scientists in *International Shipbuilding Progress* may lead to a better test technique. The authors of that paper derive from a simplified differential equation for the ship's manœuvring the factors T and K; and they indicate how those factors can be determined by experiments. A low value of T means a quick reaction by the ship when a rudder angle deviation has been applied. A high value of K represents the ability to make small turning circles at a given rudder angle. Accepting such factors as a standard, one could build up statistical data and get a criterion for the best rudder and propeller arrangement for a given type of ship.

In this respect it may be of interest to mention the results of manœuvring tests with two models of a harbour tug, one of them having the normal single screw arrangement and the other having a Kort nozzle and two flanking rudders. Manœuvring tests in the Dutch tank in accordance with the Japanese method proved that the arrangement of the nozzle with flanking rudders was superior to the normal type of tug in manœuvring astern.

Was the application of the nozzle with flanking rudders considered by the authors, for it is certain that, if the nozzle arrangement gives satisfactory manœuvrability, there will be strong demands for its application from the viewpoint of pull rope force?

Mr. N. V. Almy : The authors state that the integration of the exhaust systems with the after legs of a tripod mast and the after corners of a wheelhouse would enable the wheelhouse to incorporate internal access from the accommodation, and I ask how it works out in practice. I see that there is direct access to the mess room, which I would have thought would have kept that compartment very cold ; also I would have thought that the light coming up from the hatchway would have interfered with the pilot's night vision.

It would be interesting if some indication could be given of the surface roughness of the propellers, in view of the paper to be presented by Mr. J. M. Ferguson on "The Effect of Surface Roughness on the Performance of a Model Propeller."

With regard to the midship section, the all welded angle is used for framing. This may lead to a reversion to the trouble with the channel frames, whereby the back of the standing flange could never be painted, once the ship has been built. I think I am right in saying that that is almost entirely the reason for the bulb angle, which would enable paint to be applied to the whole section. I notice that the floors are extended from the lower to the upper chine and the side frames are overlapped at the upper chine, and it looks as though there will be an extremely weak point at the upper chine.

Mr. J. B. Griffith : There is a statement that the use of cast iron screws has been found to be essential. In my company we had the same idea for many years. However, some years ago, I put a bronze propeller on a tug used on a river, and I feared that there might be damage to the engine or, alternatively, to the shafting. Those fears were proved to have been completely unfounded. In fact we have a number of tugs with bronze propellers, and although we have damaged a large number of propellers on occasions, we have not suffered any further damage. I suggest that this statement, that cast iron propellers are essential where the danger of propeller damage is rather great, may be an old wives' tale.

With regard to the statement that welded engine seatings make possible the elimination of vibration and alignment troubles, I would have thought that, whilst the welding eliminated alignment troubles, possibly the vibration troubles will be enhanced. Riveted seatings undoubtedly produce some additional damping.

Mr. A. G. A. Muirhead : There is a bare statement that the minimum metacentric height loaded is 3ft and I ask why this figure is chosen, for many consider that in this type of harbour tug the metacentric height should be correlated with the bollard pull and the height of the tow hook.

I ask also about the propeller tip clearance from the hull ; it is very small, and I wonder whether there has been any tip corrosion. Concerning the tank test plot, the full size prediction for free running does not seem to correlate very well with the actual figures from trial results.

As to the rudders, Mr. Venus has mentioned that the tiller arms were shrunk and keyed on, and that there were no couplings, and I ask what arrangements are made to examine the clearances at the rudder top. The time from hard over to hard over with this steering gear is given as six seconds ; I would like to know if that was actually achieved.

The film showing the tow rope breaking at 30 tons pull seems to indicate that if that is the normal size of tow rope used by tugmasters the factor of safety in the tow ropes is only two.

Mr. J. D. Sampson : To provide safety in the event of a tug being tipped, a number of tug owners have fitted various types of hook attachment which give a righting moment to the vessel when she gets into that situation. I ask Dr. Corlett whether he has considered any hook fitting of that type, since in ship canal work the tow rope is generally at a fairly steep angle.

Dr. J. F. Leathard : It seems not generally recognised that a propeller can be designed only for one given set of conditions. For instance, in this particular vessel I understand the propellers were designed for the bollard condition, drawing full power on the bollard. On the other hand, in free running at the same revolutions, the power delivered by the engine will be relatively low. There are three alternatives open to the tug designer in trying to get the best of both worlds. He can adopt an engine which will give an overspeed ; secondly, he could put in a multi-speed gearbox or, thirdly, adopt a multi-pitch propeller, the last being the most expensive solution.

In my experience of cast iron screws the greatest difficulty is to ensure that they are manufactured to an acceptable tolerance. As you can see from the paper, there was great difficulty in getting the screws to an acceptable tolerance, and it is difficult to predict performance accurately if you cannot have the propellers made to a closer tolerance than is indicated here. Furthermore, they are apt to be of greater thickness than the bronze propellers. Although that has comparatively little effect at the bollard end, it has a particular effect on the free running characteristics. On the other hand, a greater thickness increases the drag coefficient on the propeller blades, and you may lose speed on that account.

Concerning the general arrangements of the tug, I think the wheelhouse is very fine, but I suggest that consideration should be given in future designs to a more suitable arrangement of instruments. It has been suggested that the instruments could be arranged in a semi-circle in front of the wheel, and the size of the wheel itself could be reduced considerably.

Dr. Corlett, replying to the discussion, said : I agree with Dr. Van Manen that you always want a quantitative rather than a qualitative estimation of features. But in this case the tests were relative, tests of a satisfactory tug of a known type against a projected one ; and the purpose was to some extent political, to satisfy the pilots, as well as technical.

I have no experience of the use of the Kort nozzle and flanking rudders in a normal harbour tug. It is a perfectly normal arrangement with pusher tugs and it is extremely effective, but I would not agree that the advantage of the pull of the Kort nozzle is that great. In the Manchester Ship Canal context you have to remember that often there are large pieces of wood floating on the water, and the arrangement mentioned is not of much use if your tug is in dock to have her stern frame straightened. So that, reluctantly, the Kort nozzle is ruled out.

I am entirely with Mr. Griffith in his remarks on cast iron screws. But, as Mr. Gibson has mentioned, the Manchester Ship Canal Company have had a lot of experience

of broken propellers, and with tugs operating in confined waters I think there is something here which can be regarded as reasonable.

On engine seatings and vibration, I think that much depends on the type of vibration. There is a great deal of vibration trouble with loose or unduly flexible seatings, and welded seatings can avoid those troubles. On the other hand, every diesel engine has variable torque, and this can produce panel vibration and torsional vibrations of the complete hull, with resonance. We have found that in a ship with a welded structure the torsional frequency of the hull may be just enough to come into the operation of the engine. On the other hand, with a riveted hull it may be just outside ; and yet again, it may be the other way round.

With regard to propeller tip clearance, we have found with this type of hull, where the flow over the stern is of very simple character, we can use very small tip clearance. We know an instance where an 11ft screw has a tip clearance of 7½in, which is very small indeed. There is no vibration for there is no separation in the flow. If one calculated the appropriate margin and the thickness of the boundary layer and puts the tip outside that, there is no trouble.

Mr. Venus in reply said : The question of the frames being lapped on to the floors was raised particularly by Lloyd's and they were insistent on that method of connection. Concerning screws, with cast iron we can never get precise pitch and even blade shape, and I advise going for bronze rather than cast iron. The time from hard over to hard over that was required in the specification was eight seconds, but it was actually done in six seconds. But I would mention that the horsepower of the steering motor was at least double what we would fit for a competitive price.

I agree with the remarks by Mr. Muirhead concerning the factor of safety on tow ropes, and think the factor used is never more than three, and it seems highly dangerous, because there are terrific surge loads and you may have very high pulls.

We have fitted the tow hook of the German type which gives a righting moment. It is also dangerous since it slams around and has to be kept carefully under control.

The second paper presented on Wednesday morning was :

PROGRESSIVE TOWING TRIALS FOR FULL-SCALE INLAND AND SHALLOW DRAUGHT VESSELS

By J. M. Sweet, B.E.

Synopsis

The design and method of propulsion of vessels for operation in shallow and inland waters have made impressive advances in the past fifteen years. Two aspects continue to have great importance for both builders and operators, namely the extent to which experiment test tank predictions can be proved accurate in full-scale application, and the adaptation of known advantages in design to the special characteristics of the regional waterways.

This paper sets out to describe practical trials carried out under most favourable conditions in regard to weather, river conditions and tide, and records the scientific data so obtained. Comparisons are made of the resistance of typical inland and more ship-shape semi-deep-sea barges, of performance of an open screw steam tug and a Kort nozzled sister ship, and, most important, of the velocity versus power characteristics of the three methods of towing, namely abreast, astern, and ahead.

All data have been collected with scrupulous care and in great detail, and the conditions have ensured maximum reliability.

Conclusions are arrived at that could have far-reaching effects on the future of inland waterway operations in general and in the specific area in concern in particular. The comparison of full-scale results with experiment tank forecasts forms the subject of an allied paper.

Discussion

Mr. A. R. Mitchell : It is stated in the paper that on preliminary free running tests with both the Kort nozzle and the open screw tugs they were unmanageable on the shallow water course. From the fact that the tunnel tug was used for the shallow water experiments it can be deduced that her manœuvrability was satisfactory. The explanation for the better performance of this tunnel tug over the others is, in my opinion, that the propellers of diameter considerably greater than the draught of the vessel are completely housed within the tunnels, and so a lesser draught is obtained, with a corresponding increase of water under the keel, which is a major factor in manœuvrability in very shallow water.

Further information would be welcomed about the wave formation causing the steam tugs to trim so much by the bow that they grounded. Is it possible that the speed exceeded the critical speed of the wave of translation applicable to the depth of water?

For the tunnel tug "Aila" the results given show conclusively the advantages of push towing in shallow water. Taking abreast towing as a basis, astern towing shows an improvement of about 11 per cent, and push towing 24 per cent. Even in deep water, push towing showed a distinct advantage over the other two methods.

Concerning shallow water effect, a table illustrates the penalty to be paid in power when relatively high speeds are maintained in shallow water. With the "Parveen" and "Lalganj" the power went up by 28·5 and 34·6 per cent respectively with a reduction in depth of water from five times the draught to twice the draught. When you have less water under the keel than your draught, we would not be prepared to guarantee any results. In a particular case the speed in deep water was 9·5 knots, and when the depth of water dropped to 1·44 times the draught the maximum speed obtainable came down to 5·5 knots.

The trials carried out by the author for push towing were with only two barges ahead of the tug, and the barges were of a form not eminently suitable for pushing. A few years ago we built a tunnel type pusher tug, which is at present pushing a train of ten barges on an African river. The barges used by the author on the trials had a space of 18in between them, but the barges I refer to were wall sided and lashed tightly together, the fenders being replaced by diagonal cope bars on the shell, port and starboard sides inclined in opposite directions so that the adjoining barges could move up and own without the copes fouling.

Mr. W. P. Walker : When the trial programme was first discussed in detail the tests proposed in shallow water frightened me. During the war some tugs had been designed by my firm for operation in shallow water in Burma, and trials were run off Hull with one of these tugs towing the barges. In deep water all went well—the barges shouldered the wake and sat there as the runs over the measured distance were made. But it was different in shallow water, with a strong current running. The barges were either bows under ; or, when speed was reduced and we attempted to come against the current, they remained stationary relative to the land ; or high and dry in a tangle of snapped ropes.

With reference to the two different barge shapes, if the comparison be made on the basis of the same payload moved, then the "Parveen" type is some 20 per cent more efficient than the older type, in deep water. In shallow water "Parveen" is again more efficient, though the amount cannot be so precisely defined, due to the necessity for loading "Parveen" 12in deeper to achieve equal payloads. I counsel caution in the interpretation of the results obtained with the Kort nozzle and open screw tugs. It can only be said that for a tug of the "Surja" type, handling tows equal to and in excess of the designed tow, no improvement in efficiency could be traced, due to the adoption of the Kort nozzle ; and in fact there was a loss of speed when running free. Against this there would be a marked increase in bollard pull in favour of the Kort nozzle tug.

With regard to flotilla formations—pushing, pulling and towing abreast—with all types of tugs and barges tested, the optimum formation is pushing barges in single line ahead. The amount by which that is an improvement over abreast towing depends on the relative size of tug and barges, and also on their abreast separation.

It would be a fair average that pushing in line in deep water saves 20 to 30 per cent of the power required for abreast towing, while in shallow water these figures could in favourable circumstances become 40 to 50 per cent. It must also be remembered that these figures refer to flotillas operating under measured mile conditions—no wind, straight courses, &c.

Dr. J. F. Leathard : I am concerned with the propeller performance of the Kort nozzle type of tug in comparison with the open water tug. I notice from the data given that the propeller diameters for both types are practically identical, being 2in more in the open water type. I would have thought it possible to increase that diameter, for if the diameter had been 6in more, it would have gone half way towards regaining the loss of pull on the bollard in the case of the open water screw as compared with the Kort nozzle type.

The comparison of the two types on the basis of tons per 100 i.h.p. is a misleading way of estimating the performance of a tug. At the maximum power of the open water screw you get 1·14 tons per 100 i.h.p., and as you decrease the revolutions, and hence the power, the tons per indicated horsepower begin to rise. This means that it is possible to design a tug to give practically any results in terms of tons per 100 i.h.p. on the bollard, provided you make the screw big enough.

Monsieur A. Lederer (Belgium): Europeans generally take a pulling tug which at one time pulls and at another time pushes the same barges, which are constructed to be pulled. The Americans take a pushing tow boat which sometimes pushes and another time pulls the same barges, which are constructed to be pushed. A good comparison has been made with tugs which pull barges constructed to be pulled and tugs which push barges constructed to be pushed. It is possible, from such a comparison of the two methods, to arrive at the best design for the barges.

In my opinion a comparison between flotillas of two barges is not sufficient ; it is necessary to use six or eight and the best forms for pushing barges are those with rectangular waterline and parabolic longitudinal section.

In the pulling method the $V/\sqrt{L}$ decreases when the flotilla becomes longer and the resistance per ton becomes lower. The intermediate barges have the maximum resistance, due to the wake of the barges in front of them. In the pulling method the first barge navigates in the flow aft of the propeller, and its resistance increase is about

30 per cent with a rope length of about 150ft. Pushing, this effect does not arise.

Coming to the comparison between tugs with and without the Kort nozzle, I note that the screw of the "Brisha" was smaller than that of the "Surja," a favourable element for the latter tug, which had not the Kort nozzle. However, the difference in the pull at the bollard was not very much. In the case of the ships in the Belgian Congo, both the tank tests and the ship tests showed a difference of about 45 per cent.

I have a diagram showing the coefficients proposed in connection with a push-pull boat for the Belgian Congo. The tests with a model were made with open screws in tunnel, screws with the Kort nozzle and tunnel, and Voith-Schneider propellers. The diameter of the screws is 1·50m and the Voith-Schneider propellers are 2·20m and 1·00m high. For the three ships the draught is 1·20m. The best in the bollard test and for towing was the Kort nozzle, the second was the Voith-Schneider propeller, and the third was the open screw, but for free running the Kort nozzle lost its advantage.

Model tests were made in the tank for deep water and for a water depth of 3·50m. Ship tests were made on the measured mile at Leopoldville with a water depth of 8m with ships fitted with Kort nozzles and with Voith-Schneider propellers.

Mr. Sweet, in reply, said: Mr. Mitchell referred to the difficulty we had in operating the two steam tugs in shallow water, and it is correct that the critical speed of the waves was in excess of the speed of the tugs at that draught. A series of pictures we took showed quite clearly the wave overtaking the tug and lifting the stern.

I agree that you cannot compare critically the performance of pushing craft and astern towing craft unless they are specifically designed for the type of duty they have to perform. I think it is clear from the paper, however, that these trials were carried out with existing craft and, as distinct from the Belgian Congo operations, our method for seventy years or more has been towing abreast primarily for manœuvrability.

Professor E. V. Telfer presided when the meeting was continued on Wednesday afternoon with the reading of:

LOSSES OF SMALL SHIPS

By C. V. Manley

Synopsis

The paper presents in tabular and graphical form the world losses of merchant ships consequent upon casualty, the casualties being recorded under the headings of: abandoned, foundered, missing; burnt; collision; wrecked; broken up; and lost through causes unknown. The ships lost under the various headings are grouped according to size, as defined by length, and the data are examined also in relation to the length of erections and age.

Discussion

Sir Westcott S. Abell, in a written communication stated: This statistical study of the losses of small ships seems to bring out factors of the ship itself that may perhaps be the causes of loss.

Ever since my early studies in freeboard, I have held the view that small ships, under 300ft long, could do with more freeboard. In the paper it is stated that the share of casualties for lengths below 200ft continues to increase, being 36 per cent at the start of the century, rising to 48 per cent between the wars and to 66 per cent in the ten years after 1945.

The type factor must matter, for 29 per cent of losses of ships below 300ft long were of the raised quarter deck pattern, while for single deck ships with less than half covered by erections the losses were 50 per cent, and within these two types were nearly 80 per cent of the losses of small ships.

I would like to comment on the weather factor, for most of these smaller ships trade coastwise, and meet with shorter waves of greater height. I note from the paper that, up to 1938, winter voyages accounted for 70 per cent of all losses, and in the post-1945 decade the percentage was higher, nearly 73 per cent. About 1912, with the weather office help, we found that for the Winter North Atlantic some 80 per cent of severe gales took place between October 15 and April 15, which seems to accord with the losses given in the paper.

Since the question of freeboards of small vessels is in doubt, it is well to point out that the paper excludes trawlers, which, by their forward sheer, seem to be more seaworthy than other ships of their size.

Mr. J. M. Murray: This paper must be read in conjunction with two previous papers on the subject by the same author. There are three outstanding pieces of information to be derived from the tables and they are: the percentage of steamers and motorships totally lost from all causes in the last fifty years has decreased continuously; the ships abandoned, foundered or missing have decreased in numbers in approximately the same degree; and in the last casualty period the percentage of loss diminishes as the size of ship increases.

The very small numbers of ships more than 400ft long which are lost is encouraging, and when these numbers are considered in conjunction with the numbers of ships at risk it will be agreed that the losses are very small indeed. It would add still further to the value of the paper if Mr. Manley gave us the actual numbers of ships at risk.

Mr. H. E. Skinner: The paper shows how safe the world merchant marine is, but there are a few pockets where things are not quite so happy. I will confine my remarks to ships which are reported as abandoned, foundered, or missing, and to ships less than 200ft long, because it is in this area that Mr. Manley's report is most revealing. He has wisely abstained from drawing all the conclusions he might have drawn and has left it to naval architects to try to push these conclusions a bit further. We must ask whether the figures given can be used for this analysis, particularly the figures for abandoned, foundered and missing ships. If the answer is "yes" then I suggest that the hypothesis which fits the losses is lack of sufficient stability in the small vessels. None of the facts are inconsistent with it, except possibly that ships carrying liquid bulk cargoes suffer very small losses. One factor which appears is that the cargo does not move in relation to the ship; possibly the more solid bulk cargoes do move in relation to the ship. But that does not absolve the naval architect from the necessity of making provision for that, and they must design the ships with sufficient stability to cope with that condition.

The safest way to increase stability is by increase of freeboard. The virtual effect of that is illustrated by a graph in the paper, showing the percentage of casualties of single deck ships 200ft long and below from 1899 to 1955. It shows that ships with under 50 per cent erections, have a higher casualty loss than those with raised quarter deck, and they in turn show casualties more than ships with full erections. One would suppose that a shelter deck ship would have the least losses.

In the recent Rules of Lloyd's Register there is one that where ships are deficient in freeboard and have no forecastle they must be given extra sheer. I think that is a Rule in the right direction.

Mr. J. Lenaghan: When reading the paper, I wondered why some of the casualties should have occurred. One remark by Mr. Skinner I must support; for the small ship it is absolutely essential that as much freeboard as possible should be provided. That point is well supported by experience with some small ships built during the war which had only 12in of freeboard. Amongst the first twelve that went to sea there were five casualties. These occurred, not altogether because of lack of freeboard, but also from lack of knowledge of how to handle these particular ships.

It is obvious from the details given that erections are an important factor, and could the author enlighten us on the casualties of the raised quarter deck type being higher in the smaller ships; and can he explain this against the total risk of quarter deckers as a whole.

Perhaps he could throw light on the question why the casualties between 1919 and 1923 were so high, and also why the casualties in the first five years of ships' lives should be so high. The casualties for the larger ships seem to have decreased over the years, but for the small ships they have increased, and I wonder if the small ships make use of the weather reports as they should.

Another question is, if some of the ships could be fitted with steel hatch covers, would we expect the numbers of casualties to decrease rather than increase?

Mr. G. M. Boyd: Although the table showing total losses from all causes over the years indicates that the percentages have dropped, the total numbers of ships lost have remained surprisingly uniform: it would add to the value of the paper if the author could give gross tonnage figures. I should think that in an analysis of this kind it would be possible to set up an accident rate which could be related, not only to numbers, but to the time. That was done some years ago in a paper to the Royal Statistical Society, for one particular type of ship.

Mr. L. J. Brinton: If we consider the losses due mainly to stress of weather and which come under the heading of "Abandoned, Foundered or Missing," Mr. Manley has shown that the possibility of becoming such a casualty is greatest for the small ship. It should be our concern as naval architects to ascertain the causes of those casualties and, if possible, to find a solution. For this purpose it would be beneficial to further sub-divide the casualties listed under this heading into causes, such as loss of stability, broaching to, breakdown of steering gear, shift of cargo, &c. Also, where loss is caused by flooding, which of the openings are most vulnerable.

Bearing in mind that we can gain only a few inches freeboard in this way, is it necessarily the answer or even the right way to improve the safety of small ships? After all, a submarine operates safely with a negative freeboard because its openings are as near 100 per cent invulnerable as human endeavour can make them. I suggest that it would be preferable to concentrate on improving the safety of any openings in the small ship. To this end it may be necessary to consider amending the Load Line Rules, which at present stipulate that ships with up to 10ft freeboard have the same standard of closing openings, even though, with a small freeboard, the openings are in a far more vulnerable position.

(*To be continued*)

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

RAILWAYS INTO ROADWAYS

SIR,—In his letter in your issue of March 28, Mr. Spencer instanced the conveyance of 1000 tons of coal engaging only sixteen railwaymen compared with from three to five times that number of men, by his calculation, were roadway substituted for railway. But he disregarded certain facts. For instance, the average trainload—which still engages all Mr. Spencer's sixteen men—is not 1000 tons ; it is only 159 tons, or ninety passengers. And the average coal haul is only fifty-six miles, which means that within the coal's overall transit time by rail, expressed as X days (including loading, marshalling, transit and unloading), tipping lorries would each be able to complete $12X$ round trips : a single 20-ton tipper could do the job of Mr. Spencer's entire train in four days, or of the average train in sixteen hours. Britain is perhaps too small a country for railways.

However, it was the all-important subject of manpower that gave rise to Mr. Spencer's calculation. May I offer an alternative calculation, as follows : roundly, British Railways employ 600,000 people to run daily 40,000 trains yielding 1,000,000 train-miles ; accordingly, the daily output of fifteen railwaymen is one train that runs 25 miles. For each day of the year the fifteen men each draw the equivalent of six hours' pay, which that average train has to earn for them in one-and-a-half hours ; its " crew " is therefore sixty, not the commonly supposed three, nor even Mr. Spencer's sixteen.

He went on to echo the British Productivity Council on the need to reduce " non-productive labour, such as transport, to a minimum," thereby raising the national aspect of this manpower problem, on which it will be relevant to quote the British Transport Commission : in its 1956 report it gave an indication of the proportion of Britain's transport burden borne by B.R.'s 570,547 army of employees. The actual words of the report were : " All the transport activities operated by Commission-owned undertakings together represent less than one-third of the total transport activity of the country." Under those circumstances, and in view of the licensing of an extra million motor vehicles in the meantime, it must now be very doubtful whether B.R.'s share of Britain's transport activity is as much as one-seventh. If all other forms of transport used whole-time manpower on the same scale as B.R., there would be 4,000,000 transport employees among our 23,000,000 working population ! The actual number (including B.R.) is about 2,000,000. Plainly the railways are a glutton for manpower : no wonder the average train crew works out at sixty.

This manpower discussion is relevant also to Mr. Trillo's eulogy of safe rail travel in your same issue of March 28. The passengers certainly are safe enough (incidentally, according to the Royal Society for the Prevention of Accidents, bus passengers are equally safe), but the 570,547 railwaymen are in a very different category. As recently as March 20 the National Union of Railwaymen was pleading for higher wages partly on the grounds that the railway industry was still the third most dangerous in the country. Are we justified in perpetuating so dangerous an industry, imperilling fully 1 per cent of the entire population, when there is an existing alternative ?

Unfortunately, as this correspondence has shown, the issue is obscured by our lacking any true picture of that existing alternative—road transport. It is of but stunted growth in Britain : loaded down with taxes ; its setting a system of highways that are more truly byways. Give it the run of that sublime route system at present overlaid with rails and it will become something altogether different : its speed, safety, cost, comfort, reliability, working capacity, will all be changed—surely for the better.

T. I. LLOYD

London, E.C.1,
March 31, 1958.

SIR,—Neither Brigadier Lloyd nor Mr. Gordon England tells us whether we could expect to be able to write legibly while travelling on the super-autobahnen that beguile them. Mr. England implies that he could only guess how many millions of pounds could be saved by prohibiting parking. This confirms my impression that the same method was used in arriving at the numerous millions that the super-autobahnen are promised to save us. But he does not attempt even to guess how much time we should lose in using them instead of travelling by rail.

I do not " envisage " any kind of road or vehicle and I do endeavour to distinguish between change and progress, but as a passenger (regrettably more troublesome than a statistic) I do ask the progenitors of a bright scheme to tell me (if and when they should get down to practical matters) how much worse off I should be if it were inflicted on me.

W. A. TUPLIN

Sheffield,
March 22, 1958.

SIR,—In reading recent articles in yours and the National press I am very surprised by the narrow mindedness of contributors on our transport problems. It is an improvement in our transport facilities we seek, not a reorganisation. The present road system could be improved very quickly and cheaply by suitably by-passing present bottlenecks. Inspection of local conditions would no doubt produce numerous examples which could be overcome by the provision of a bridge in the first instance. A good example would be the provision of a bridge or viaduct to carry Southend to London traffic over Gallows Corner roundabout, simple, relatively cheap and solving a major problem on Sunday evenings in particular.

The capacity of any major road is not in many cases determined by the road but by the capacity of the access to it. I feel this will be the case on the Yorkshire motorway. This scheme should have been preceded by joining the A2 and A5 roads by a " Watling Street Viaduct " to by-pass London and give a direct link with the Midlands to Dover and the Continent. It should have been possible to-day to travel by road from Aberdeen to Dover without the Yorkshire motorway at a steady maximum speed of 40 m.p.h. to achieve a 35 m.p.h. average without being impeded by traffic lights and speed restrictions, by the provision of suitable by-passes, double decker roads and bridges.

The present railway system is not being worked at anywhere near even quarter full capacity. The Midland Region states that, by building new marshalling yards, freight trains could be run at four minutes headway on present tracks; in fact that is their intention. This suggests a possible 15,000 tons per hour twenty-four hours per day. If by building marshalling yards, fitting brakes to all freight vehicles, and by imaginative modernisation such as that at Barking, all tracks could carry heavy freight trains at such headways, Brigadier T. I. Lloyd's suggestions would die a natural death.

The Cinderella of the British Transport Commission, the inland waterways system, could also be improved to carry more merchandise more quickly. The reduction in the number of locks and simpler lock gates, the straightening and removal of tortuous sections, would all improve journey times. The widening of canals would give greater carrying dapacity.

A. T. BUTCHART

Bedford,
March 29, 1958.

SIR,—Mr. Gordon England is rather out of date in his experience of the German Autobahnen. I have driven a few hundred miles on them during the last few years, and find it a most dangerous and nerve-racking business.

On busy sections (which are the majority) the right-hand lane of each carriageway is usually occupied by heavy lorries and trailers advancing nose to tail at about 45 m.p.h., overtaking one another from time to time. The private cars are obliged to use the left-hand lane. The effect is similar to that of driving along a wall that is not only moving forward at 45 m.p.h. but liable at any moment and with little or no warning to bulge out in one's path.

Mr. Gordon England would do well to inform himself of the latest progress in the design of railway vehicles. By good design there is to-day no difficulty in eliminating the bad riding of which he complains.

C. J. O. GARRARD

Sutton Coldfield,
March 24, 1958.

TURBOBARILLET

SIR,—In your article on "Gas Turbines in 1957," published on page 61 of the January 10, 1958 issue of THE ENGINEER, the following statement is made regarding Mr. M. de Valroger's "Turbobarillet" turbo-prop engine that "The principal disadvantage seen by the author is the high power consumption in windmilling any gas generator shut down, which is estimated at 20 to 30 per cent of its power output." I believe this statement would apply only if the gas generators were geared together. The schematic view of the "turbobarillet" engine included in the article shows the gas generators free from each other. In this case, it is not obvious at first in which direction the shut down gas generator would rotate. This would depend on whether the static pressure in the exhaust duct is higher than the compressor inlet pressure and these pressures are affected to a considerable extent by the speed of flight. It is, therefore, conceivable that under static condition, the pressure in the exhaust duct be higher than at the compressor inlet, in which case the shut down gas generator would windmill backward and hot gases would recirculate to the inlet of the adjacent compressors, a condition which is obviously undesirable.

The operational characteristics of this type of power plant require careful study before any generalised statement can be made. I trust that these comments may be of interest to you.

MARCEL PIRY

Fairchild Engine Division,
New York,
February 14, 1958.

THE BRITISH MACHINE TOOL INDUSTRY

SIR,—In a statement entitled "The British Machine Tool Industry," recently published by the Machine Tool Trades Association and reviewed in your March 7 issue, the machine tool is rightly described as "the basic machine of all present-day production"; but there is even more in it than that. Machine tool design, in making our present engineering and other products possible, is the basis of our present-day civilisation. It demands a very high development of scientific and engineering ability in design and construction, both on the theoretical and practical sides, and provides the finest possible training ground for engineering designers.

A nation with a vigorous, progressive and forward thinking machine tool industry has the finest possible human and material foundation for the rapid development of all the industrial arts, both of peace and war. The engineer with a good machine tool design training can turn his hand to the design of almost anything else with confidence. The nation without such an industry is dangerously dependent on others. In view of this, and of the suitability of the work to our national genius it is surprising, to say the least of it, that the industry is usually regarded by others, and even by itself, as mainly a commercial activity, and that, in comparison with Continental nations, it has only very recently attracted any attention at a high scientific or intellectual level.

Apart from instrument work, which goes back earlier, the foundations of the machine tool industry were laid by the work of Henry Maudslay (1771–1831) and his pupil, Joseph Whitworth (1803–1887). These men gave us a good world lead, and Whitworth, by putting a substantial sum from his industrial profits into educational scholarships, did his best to see that we should retain it. By about 1905, however, this lead had been lost. The scholarship system had not been extended by Whitworth's successors to keep pace with the expansion of industry; and we now lag so far behind that it seems unlikely that we shall ever catch up. These are serious words, and they demand supporting evidence.

In the Science Museum there is an early bevel gear shaping machine of about 1890, designed by J. Buck, a foreman at Robey Smith's works, Lincoln. There are no up-to-date British bevel gear cutting machines on the market to-day. Nearly all the British machine tool makers act as agents for foreign firms, and meet this country's needs for these, and many other precision machine tools, from foreign sources, evidently viewing the rake off on the sale of a foreign machine as being as well earned as the profit from the sale of a British-designed and built machine. This may well be so from a commercial point of view, but there is much more in it than that.

The published statement gives a figure of 73 per cent of the machine tools needed for the country's last war effort as having been produced in this country. This may be so, counting each tool, whatever its character, as one unit; but the imported 23 per cent were largely the indispensable precision tools not made in this country at all, e.g. large jig borers and precision gear cutters, without which we could not have got on with the job. Even now, the whole of our defence and aircraft material, with hardly an exception, is dependent for its existence, in one way or another, on foreign designed and built machine tools and components, because the British equivalent just does not exist. The tool rooms of most up-to-date engineering works, where real precision is needed, are mainly equipped with machines from Switzerland, America and Germany. These show, in general, more vitality and a higher brain content than the nearest British equivalent, as the agency system has had a deadening effect on British designers. Machine tools, like many other things, are the work of men, rather than of firms. Who, at the present time, or in the more recent past, are the intellectual heirs of Maudslay and Whitworth, men who could keep this nation in the lead it once held?

In view of the national importance of the vitality and scientific ability of the industry it is strange that so little attention has been given to it by national bodies such as the Royal Society, the university schools of engineering, the Royal Society of Arts, or even the D.S.I.R. As far as can be seen, none of these bodies nor even—until very recently—the professional institutions, seem to have given any attention at all to what is probably the most vitally important industry in the whole country. Unless conditions are created which make machine tool design attractive to men of outstanding talent and ability, as well as experience and skill, we shall never catch up.

This tendency—emphasis on the profit rather than on the product—is reflected through many other industries in this country. Far too many of the more interesting exhibits at the last machine tool exhibition at Olympia were foreign machines, or were made in this country under licence from foreign designs; and the same applies to the more recent engineering exhibition last autumn.

No; our machine tool industry, though capable of meeting most of the needs of other industries from such world sources as are available, has little reason to be complacent. Largely owing to its neglect of the intellectual content of its own product, we, as a nation, are in a fair way to losing our ability to earn our own living in a competitive industrial world.

HUGH CLAUSEN

London, N.W.2,
March 20, 1958.

ORIGIN OF THE WORD "MIL"

SIR,—Browsing through an old volume of THE ENGINEER, Vol. 26 (1868), I came across a short article on page 406 by F. L. Pope, "On a Standard Wire Gauge." This particular article struck me, because there is a reference to the introduction of the word "mil" for a thousandth of an inch. F. L. Pope says in his article: "Mr. Joseph Whitworth of England, proposed in 1857 the adoption of a gauge, in which the number of each size corresponded to its diameter in thousandths of an inch. This was, however, too radical a form to meet with general favour, and the proposed system never came into practical use. The following year Mr. James Cocker, of Liverpool, proposed a new gauge, differing but little from those in ordinary use but made more regular in its gradations. He also introduced the word 'mil,' to designate thousandths of an inch, which has been found very convenient in practice."

Unfortunately, I have thus far been unable to find any reference where James Cocker might have published his proposal for the introduction of the word "mil." I wrote, a few months ago, to the Liverpool Engineering Society, whose Hon. Secretary went to some trouble to obtain information of the man James Cocker. There are entries in the Liverpool Directories for a James Cocker, Merchant. First entry is in 1847, while the 1860 directory and onwards contain no mention of James Cocker. The Liverpool Engineering Society was only founded in 1875 so that Cocker possibly could not have been a member of that Society.

Otherwise, the subject seems to be quite interesting because 1858 would be "mil-Centenary" and, furthermore, the origin of the word "mil" certainly has not been traced yet. The *Oxford English Dictionary* quotes an 1891 reference.

It seems that the article by F. L. Pope mentioned above was reprinted in THE ENGINEER from the *U.S. Telegrapher* and maybe some more information could be found there; but this seems to be a rather vague suggestion.

Unfortunately, I do not have access to the 1858 THE ENGINEER. It could be that these volumes contain an article by Cocker.

I would be very glad if this communication

would contribute to the clarification of the origin of the word " mil."

H. DRUBBA

Essen, Germany,
March 11, 1958.

[Our issue of January 29, 1858, contains a description of a wire gauge under a patent dated June 16, 1857, and granted to James Cocker of Liverpool. The article, however, contains no reference to the word mil. The dial of the instrument was to be " graduated by preference to a decimal scale."—Ed., THE E.]

Book Reviews

The Ultra High Frequency Performance of Receiving Valves. By W. E. BENHAM, B.Sc. (Lond.), F.Inst.P., and I. A. HARRIS, A.M.I.E.E., A.M.Brit.I.R.E. Macdonald and Co. (Publishers), Ltd., 16, Maddox Street, London, W.1. Price 28s.

THE aim of this book is to analyse mathematically the limitations of conventional valves in the v.h.f. and u.h.f. ranges where electron transit time adversely affects performance. The standard of mathematics is not beyond that of the engineering and physics graduate and the authors interpret their results physically. It is a book for the specialist, and more particularly the valve specialist, though the circuit engineer will find something of interest in Chapter 8 on the valve as a four terminal network and in Chapter 10 where the effect of transit time on noise factor is considered. In the latter chapter theoretical calculations of noise factor increase due to transit time are shown to give results in reasonable agreement with measurement.

The first chapter states the problem of transit time increase of input conductance in terms of induced currents in grid-cathode and grid-anode circuits, and refers to the effect of the electrode lead inductance and of interelectrode capacitance as well as of cathode coating interface impedance. The authors do not clearly explain why they start with electron flow (Fig. 1.1.) and then switch to conventional current flow (Fig. 1.2.). This short chapter could with advantage conclude with an introduction to the rest of the book. Chapter 2 is a useful restatement of the fundamentals of current flow in interelectrode spaces, and these fundamentals are employed in the next two chapters dealing with high frequency characteristics of ideal diodes, triodes and tetrodes under small signal conditions. A short paragraph on " bunching " of electrons in a drift space and the possibilities of velocity modulation is included in the chapter on diodes but is not pursued because the authors state in their preface that they are dealing only with ordinary valves. One of the few misprints occurs here in Fig. 4.1a. where the grid-cathode spacing should be designated d_1 and not d_2. Chapter 5 indicates the modifications necessary in the idealised analysis to account for the effect of the initial velocity of the electrons. Irregularities of current and transit time due to initial velocity, the electric field configuration in the cathode-grid space and the lens action of the grid-anode field are also considered.

Induced currents in retarding fields, the subject of chapter 6, lead to a consideration of the diode with negatively biased anode (chapter 7) which gives conditions similar to those met in the grid-cathode space of amplifier and mixer (frequency changer) valves. Chapter 9 on the u.h.f. operation of valves as oscillators, power amplifiers or frequency changers with large input signals seems rather an afterthought, for the authors admit that no satisfactory large signal transit time theory has yet been developed. With so little to go upon the material hardly acquires the dignity of a chapter and could better have appeared as an extension of one of the small-signal chapters. The last chapter on noise factor is of particular interest to the v.h.f. and u.h.f. receiver designer, and apart from developing the theory of noise in diodes and triodes the authors obtain expressions for the noise factor of triodes in common cathode or common grid (grounded grid) connection. The resistance of the cathode coating and the reflection of electrons from the anode are shown to have important effects on the internally generated noise.

Minor criticisms are the use of the asterisk for two entirely different purposes, namely, to denote conjugate values and to draw attention to footnotes. In one or two places the meaning is obscure, notably on page 130 in the bracketed information where G_1 is defined. On page 132 is given an expression for δi_e but a meaning is not given to δi_e until a page later.

Materials of Civil Engineering. By J. P. M. PANNELL, M.I.C.E., M.I.Mech.E. Hutchinson and Co. (Publishers), Ltd., 178–202, Great Portland Street, London, W.1. Price 21s.

Materials of Civil Engineering is not, strictly speaking, a text book ; nor is it a book for advanced or specialised study, since each of the subjects dealt with is treated more fully in specialised volumes. If an analogy can be made with the study of a language, the book is rather like the " reader " which gives a practical understanding balancing the text book of grammatical rules. Here we have an exposition of the principal materials encountered by the civil engineer, not in terms of " strength of materials " but in a form which gives a background to the practical experience of using these various materials in constructional works. The subject matter covered by the book probably is not required by any particular examination syllabus ; it has apparently been selected for its practical value and the civil engineering student or the practising engineer will find a great deal of knowledge conveniently amassed in it, which might prove of more direct value than some of the subjects in the examination syllabus.

The subject matter of the book is as follows. The principal engineering soils are described, and basic principles of soil mechanics and of testing soils are explained. " Rocks " are similarly described in the second chapter. There are four chapters on timber, the first a general one delineating the properties and structure of wood and specifications for its use ; then European timbers, timbers of the western hemisphere, and timbers of Africa, Australia, and Asia are described. The extraction and metallurgy of iron is explained in a chapter entitled " Iron " which is followed by chapters on the manufacture of steel, and on the shaping and use of steel. Aluminium and its uses are given a chapter, and then there is a chapter on cement and one on concrete. Bituminous materials, paint, rubber, and plastics are the materials discussed in the final chapter " Products of the Industrial Chemist."

All these various topics are presented with a very practical bias ; they are not just " digests " of information but bring out those facts which an engineer engaged in constructional work will need as a background. Indeed, the foreword suggests that the book might be considered as an introduction to the British Standards dealing with the various materials. The presentation is attractive and the descriptions are compact and precise.

Elementary Nuclear Physics. By W. K. MANSFIELD, *Nuclear Engineering*, Monograph No. I. Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 10s. 6d.

THIS is the first of a new series of monographs on nuclear engineering subjects. It embraces so broad a field, however, that to call it a monograph is perhaps not altogether appropriate. The author's attempt to compress an account of modern atomic physics into about sixty pages is certainly a gallant one, and he has to a surprising extent succeeded in his task.

The treatment is, in the publisher's words, " intended for university and technical college students, research assistants and qualified technicians who require a broad understanding of those topics of nuclear engineering outside their own field of study," and to one who is not a stranger to modern physics the outline presented is fair. Provided that nobody is misled into regarding it as a substitute for a textbook, or as a sort of " Physics Made Easy," the publication is a useful one, but to those whose notions have not been properly attuned the book may be merely bewildering. The author himself seems sometimes a little uncertain as to the nature of his audience. Thus, after looking at atomic and molecular weights and the kinetic theory of gases, he describes atomic structure on the usual analogy with the solar system : he then introduces valency on page 5 as " the number of hooks the atom has for making chemical compounds," states at once that this " is determined by the excess, or deficit, of electrons over and above those necessary to complete a shell," and then, after three or four intermediate pages making no reference to valency, proceeds to discuss exchange forces and the covalent bond. A reader who is fresh enough to the subject to be enlightened by the hook metaphor will like this to be enlarged upon, and may well find incomprehensible the matter on exchange forces, while a reader who is at home with exchange forces hardly needs the homely illustration. The book cannot satisfy the whole range of readers between these two because it cannot provide the full development of its subject, from simple beginnings onward, in the way a good textbook does. The same limitation necessarily applies to subsequent chapters. They are devoted to, respectively, the nucleus, radioactivity, the neutron, the interaction of matter and radiation, and the detection of the latter. A useful detail is a page at the front of the book setting out the notation—particularly useful since several symbols are employed with more than one meaning.

Boldly drawn diagrams illustrate the book (which is bound in thick paper covers), and there is an index.

Books Received

Safety Aspects of Nuclear Reactors. By C. Rogers McCullough. D. Van Nostrand Company, Ltd., 358, High Street, Kensington, London, W.14. Price 64s.

Steam Locomotive Design. Part II. By R. H. Mann. The Association of Engineering and Shipbuilding Draughtsmen, Onslow Hall, Little Green, Richmond, Surrey. Price 6s.

A Treatise on the Internal Mechanics of Ball, Tube and Rod Mills. By H. E. Rose and R. M. E. Sullivan. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 25s.

Aerothermodynamic Test Plant

On Wednesday last week Air Marshal Sir Geoffrey Tuttle, Deputy Chief of Air Staff, formally opened the high altitude test plant of Bristol Aero-Engines, Ltd. A number of illustrations of the plant appeared on April 4, page 502. We give here an outline description of the facility, which is principally used for testing ramjets.

THE engine test plant used by Bristol Aero-Engines, Ltd., for the development of ramjet engines is the only one in operation in this country in which the test cell can be evacuated to reproduce the conditions of running at high altitude. The pressure in the test cell can be brought down to 1½ lb per square inch, for zero mass flow, by steam ejectors. The range of altitudes and air speeds that can be simulated depends upon the size of the air stream required ; the facility as at present constituted can test ramjets up to 32in in diameter, but by doubling the number of steam ejectors, 36in engines could be accepted, even without increasing the size of the air ducts. The pipework at present installed is of mild steel and, thus, working temperatures are limited to 450 deg. Cent. ; Mach number 3·5 can therefore not be exceeded until chrome-molybdenum piping is in use. The envelope in which tests are possible is limited in various directions by air supply, ejector capacity, heater capacity and, to a less serious extent, cooler capacity. The envelope for a representative engine is reproduced in the diagram overleaf.

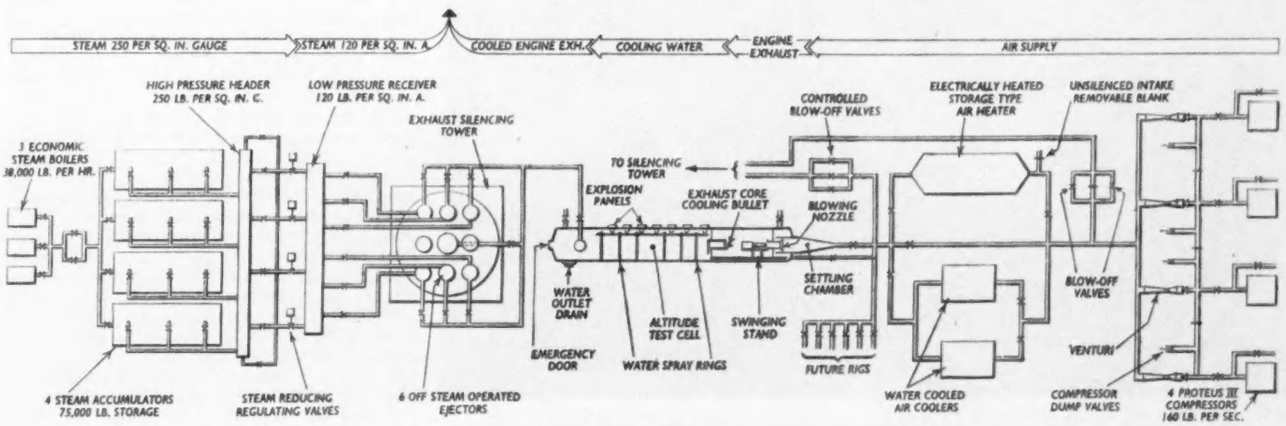
The general arrangement of the plant can be seen in the diagram below. There are four main modes of operation, i.e. low, medium and high altitude, and transients. The ejectors are run for high and medium altitude tests, and compressed air is supplied to the plant for low and medium altitude tests. The air supply, which reaches the building through a 3ft diameter overhead main, is derived from "Proteus" Mark 111 compressors housed in what is called an air station. Up to four compressors can be used, and to allow the full installed electric power to be used by either two or four, the motors are coupled together into two sets : when high pressures and low mass flows are required, two of the compressors are disconnected. The motors have a total rating of 26,000 h.p. for two hours or 21,000 h.p. continuous ; two compressors can be driven at 12,000 r.p.m. to give 84 lb per second at 8 atmospheres pressure and 315 deg. Cent., or four at 11,000 r.p.m., delivering 150 lb per second at 6 atmospheres and 260 deg. Cent.

Within the main building of the plant are a heater and a pair of coolers, through which all or part of the air can be passed. The heater has a 36-ton matrix which can be charged in four hours by 1500kW electric elements ; an air flow of 80 lb per second can be raised from 260 deg. to 350 deg. Cent. for ten minutes, and outlet temperatures up to 450 deg. Cent. are available. To provide a close to constant outlet temperature, louvres distributing the air between the 3ft diameter central passage and the gaps between the 10ft diameter storage discs are controlled automatically. The two coolers are fed with up to 50,000 gallons of water per hour, and can reduce the maximum air flow of 160 lb per second to 95 deg. Cent.

Projecting from the building is the test cell, 75ft long and 10ft in diameter. It was considered necessary to have a door which spoilt the symmetry of the cylinder in order to give adequate access to the test bed proper and the result was a difficult pressure vessel which was fabricated by Babcock and Wilcox. The cell weighs 108 tons and the door, which is 20ft long, 10 tons : it is held closed by a series of bolts in shear. The complete cell has been tested to extreme pressures of 90 lb and 1·0lb per square inch absolute.

The air enters the cell through one of a selection of fixed-geometry nozzles suitable for Mach numbers up to 3. Facing the nozzle is mounted the ramjet under test, supported on a swinging stand to allow direct measurement of thrust. It is important to realise that to produce realistic conditions within the ramjet it is necessary only to have a sufficiently low pressure in the test cell to choke the propelling nozzle : however, if the ambient pressure is greater than that in actual flight, the thrust will be affected, and hence direct assessments of thrust cannot be made over the whole of the envelope indicated —in particular, not near the "ejector" boundary.

The test cell has water-cooled glass windows facing the control room, and also a series of glass windows which are shattered by explosive charges if the pressure in the cell during a test exceeds 25 lb per square inch absolute, thereby safeguarding the cell against bursting. At the rear of the cell are water sprays to cool the exhaust, which impinges on a fixed bullet to shorten the length of cell necessary.



Diagrammatic layout of steam and air systems

Exhaust gases leave the cell by an underground duct which includes two 5ft diameter wedge gate shut-off valves : to reduce the risk of damage by an accumulation of unburnt fuel vapour in the tunnel, Graviner explosion suppression equipment is installed to flood the duct with chlorobromomethane if light is sensed by the detector.

The duct divides into three before reaching the silencing tower, one branch leading to a plain blast pipe and the other two dividing again to run to three ejectors each. The ejectors may be fitted with alternative nozzles to pass either 33 lb or 40 lb per second of steam each; various combinations of ejectors can be used, and at maximum flow the accumulators can be exhausted in six-and-three-quarter minutes. The 98,000 lb of steam expended can be replaced in two-and-a-half hours by the three oil-burning boilers. A water treatment plant able to process 40,000 lb per hour is provided, together with storage for 12,000 gallons of make-up. Water for the boilers, the coolers and the sprayers is all drawn from a 250,000-gallon reservoir.

The ejectors and air discharge outlets are located in a silencing tower 100ft long which extends 20ft below ground level. Other conspicuous features of the installation are the surprisingly large tank farm for engine fuel, with six tanks totalling 26,000 gallons : there is, however, no hint of fuels other than hydrocarbons being used.

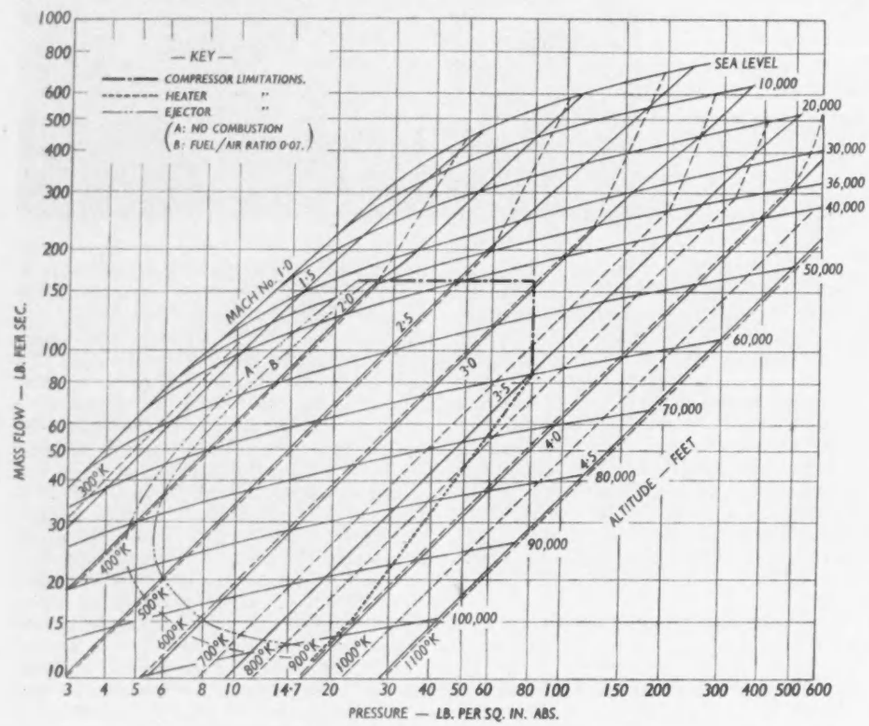
The control and instrumentation compartments house comprehensive measuring gear for thrust, fuel consumption, pressures and temperatures. In addition to the recording of research phenomena on Honeywell-Brown chart recorders, the main instruments are duplicated on an auto-observer and recorded photographically.

The fourth mode of operation above-mentioned is the simulation of acceleration of an engine through the atmosphere. For this transient condition, the air delivery is initially passed through the blow-off valves, and these valves are then closed, while the cell delivery valves are opened. This is normally done according to a predetermined programme, but apparatus has been developed with which the desired conditions, particularly Mach number, at the nozzle are specified over a given time and a servo system drives the valves to produce the desired results.

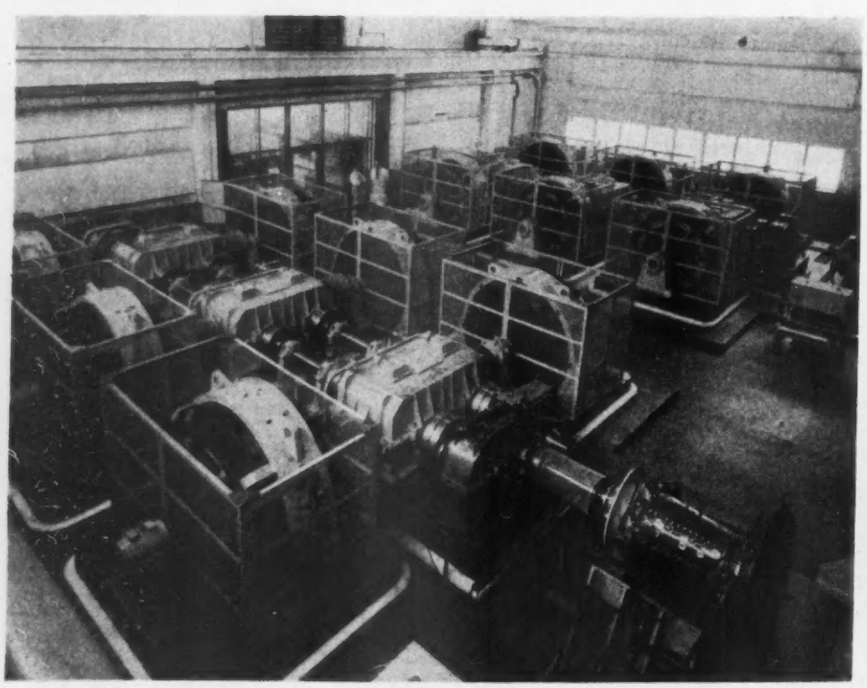
An interesting feature of the work of the plant is that much use is made of slotted nozzles, analogous to the slotted working sections of transonic tunnels. These have the advantage that they can be driven through a range of Mach numbers by varying the air supply : the limit to their use is, of course, the wastage of air through the slots at the highest flows.

On a tour of the plant after its opening, we observed many interesting intake configurations being tested in model form, including three-shock intakes with a change in taper of the centre body and a cascade intake with two circular rings in between centre body and outer lip. In view of the fact that the intake of the " Thor " has never been seen in public, it may be worthy of record that in the opening ceremony a " Thor " was ignited at a simulated Mach 2 at 30,000ft : for a 16in diameter engine this corresponds to approximately 1800 lb thrust.

The cost of the plant, as distinct from the buildings and services, was, we understand, met by the Ministry of Supply.



Testing range for 21¼in diameter ramjet



Two groups of six electric motors can be used to drive two or four " Proteus " compressors

Naval Architects' Annual Dinner

THE annual dinner of the Institution of Naval Architects was held at Grosvenor House, Park Lane, London, on Tuesday, March 25, with the President, Viscount Runciman of Doxford, in the chair. The Earl of Selkirk, the First Lord of the Admiralty, gave the toast of " The Institution of Naval Architects," and commented that the country depends upon the design and quality of our ships. Although it may be considered that aircraft were unduly favoured, he thought that the shipping industry demonstrated its virility by standing on its own feet, and then went on to be optimistic about the recovery from conditions of low freight rates, since the rise in the standard of living throughout the world meant expansion of trade. On the question of propelling machinery, he felt that we must resist the temptation to develop and install a nuclear power plant in a ship solely for propaganda purposes, but must await the production of a plant which was an economic proposition. Viscount Runciman remarked upon the enormous growth of world shipbuilding output, which implied the renewal of a ship every twelve years. This position of there being more ships than merchants could use meant a period of intense competition and under such circumstances, the president continued, owners must place orders as dictated by price and delivery. It was quite useless, he said, in the shipbuilding and shipowning industries, to try to improve the competitive position by the introduction of any form of restrictive practice. The president also proposed the toast of " The Guests," to which M. Jean Chauvel, the French Ambassador, replied.

Manvers Main Carbonisation and By-Product Plant

A new coking plant installation of the National Coal Board at Manvers Main, Wath-on-Dearne, is designed to carbonise a million tons of coal a year. In it there are now combined on an extended site a rebuilt and modernised coking plant and a large new plant. In the completed plant there are now 137 coke ovens in the carbonising section and a large conventional equipment for the recovery of by-products. This reconstruction and development scheme has cost some £9,000,000 to complete.

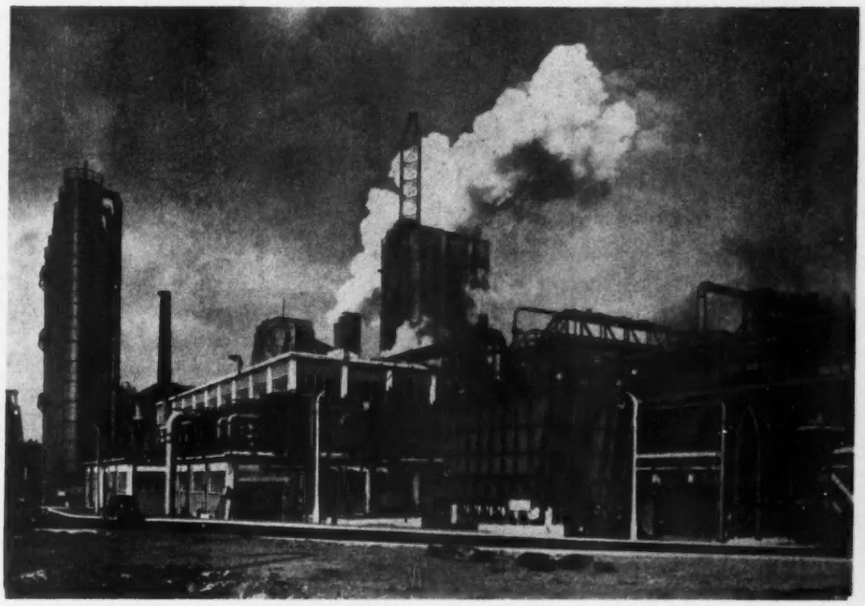
A COKING and by-product plant of the North Eastern Division of the National Coal Board recently completed at Manvers Main, Wath-on-Dearne, is the largest of its kind in the country. It is designed to carbonise 1,000,000 tons of coal a year, and this coal is drawn from the central preparation plant of the adjoining colliery. In addition to an annual production of 650,000 tons of blast-furnace, industrial and domestic coke the plant will have an annual output of 50,000 tons of crude tar, 8500 tons of ammonia products, 4000 tons of concentrated ammonia liquor and 3,500,000 gallons of crude benzole; as well as 19,500,000 million cubic feet of gas per day. The accompanying illustrations show some of the installations of the new plant.

The first coking plant at Manvers Main was a battery of thirty-six Koppers regenerative ovens built in 1906; and batteries of fourteen and twenty-two Simon-Carves waste heat ovens were built in 1912 and 1917 respectively. When it was decided to remodel the whole plant in the 1930's thirty Simon-Carves rich gas underjet ovens and a new by-product plant were built on the site of the old waste heat ovens. A further fifteen Simon-Carves ovens were ordered in 1934, the existing coal and coke handling plant and by-product plant having enough capacity to deal with this extension.

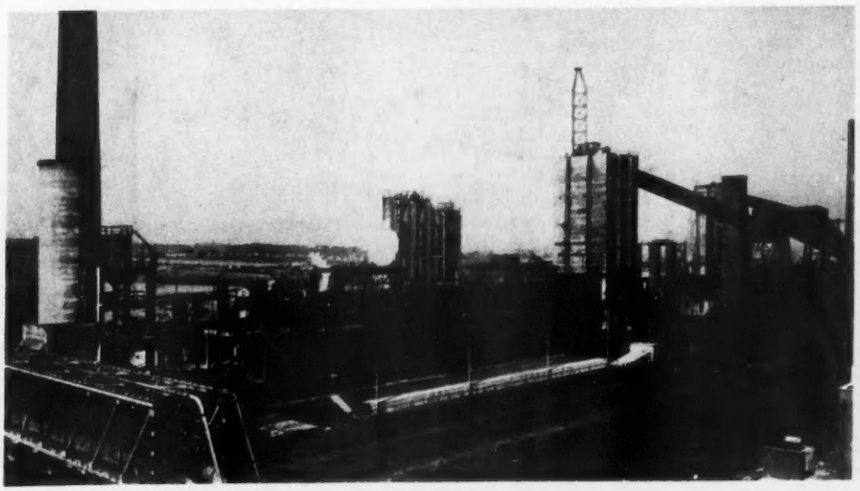
When the N.C.B. took over the plant it was decided to rebuild the batteries, and this work was carried out in stages in order to maintain gas supplies. The first stage was the building of seventeen new Simon-Carves compound ovens; the fifteen-oven battery was then rebuilt, after which the thirty-oven battery was remodelled as two blocks of thirteen and fourteen ovens respectively, This rebuilding was finished in 1953, and all the rebuilt ovens retained the rich gas heating system.

The colliery development scheme, which was being planned during the rebuilding of the ovens, called for a central coal preparation plant at Manvers Main to treat all the coal from Manvers, Wath, Kilnhurst and Barnburgh collieries, coal from the first three to be wound at Manvers and that from the last brought overland. As the estimated output of saleable coal from this plant was 12,000 tons per day, including a large tonnage of coking smalls, and as the plant was well placed with respect to the gas grid, it was decided to increase the Manvers carbonising capacity to a throughput of 3000 tons of coal per day. The coal preparation plant treats high, medium and low rank coals, three rows of blending bunkers enabling each type of coal to be kept separate and blended as required. As the old and new ovens have separate coal service bunkers and coke wharves, the coke from the two sites can be kept separate, thus enabling two types of coke to be separately produced, stocked and handled.

When the new plant was being planned the extension of the old site of the coke-oven batteries was limited by the need to retain the original small oven dimensions of 38ft 6in over the sole, 13ft 3in high and 1ft 6in mean width giving a weight of 14 tons as charged. To the rebuilt ovens listed above there has been added a block of twelve new compound ovens, and the completed battery gives a throughput of about 1320 tons of coal a day. A new chimney was built to serve all seventy-one of these ovens on the old site. On a new site there has been built a battery of sixty-six ovens in two blocks of thirty-three. These ovens have chambers 44ft 7in long over the sole, 14ft 9in high, 1ft 5½in mean width and they each take a weight of 17·8 tons as charged. This battery has a throughput of 1570 tons a day.



New by-product plant with benzole scrubbers (left), exhauster house (centre) and naphthalene washers and regeneration unit in the foreground



Coke side view of new sixty-six-oven battery

In order to save ground space the ram track of the new battery is carried about 19ft above ground level, the space below being enclosed by brick walls to provide locker rooms, shower rooms, mess rooms, workshops and an electric substation. It has two complete sets of oven machinery and the travel motors of the ram machines have "Microsen" gear, which enables the machines to be centred quickly and smoothly. The ram beam can be operated at reduced speed by a compressed-air motor in case of power failure. The coke guides and coke side door extractors are separate machines with their own travel drives.

Charger cars of portal frame design have their travelling wheels mounted in bogies, the bogie frames being riveted to the car chassis on one side and on the other side carried by pin bearings with hydraulic dampers. The three-point suspension provided evens out

the load and prevents "crabbing" and vibration, which greatly reduces wear and tear on the oven top brickwork.

The plant is fitted with self-sealing oven doors throughout, the new sixty-six oven battery and three of the batteries on the old site having a new design of latch gear. This door, known as the "G" type, is tightened on to its seating by its own weight instead of by the conventional rose and screw. Two toggle arms pivoted to the door body engage with the latch hooks, and the weight of the door acting through the toggle arms forces the sealing strip on to its seating. To remove the door the extractor head takes the weight in the normal manner, and the toggle arms are then raised until the latch bars are clear of the hooks by handwheel operation of a screw-jack in the linkage between the arms; the door is then withdrawn in the usual way. This "G" type of door has the advantage that the closing force is constant and strain on the latch hooks and sealing strips is avoided.

Coke Handling and Screening

The batteries on the old and new sites have separate conveying systems to the main coke screen house, so that different types of coke can be kept separate if necessary.

The wharf conveyors from the two sites meet at a junction tower, from which two conveyors cross the main railway line in a single gantry to another junction tower on the far side. From this tower two further conveyors lead to the main reinforced concrete screen house, where each conveyor feeds its own line of grizzley screens for run-of-oven coke. Overs from the grizzley screens may be delivered either to rail wagons by boom loaders or to the stocking ground. Throughs (under 2½in) may be fed either to secondary screens or to the stocking ground. A proportioning device enables some or all of the run-of-oven coke to by-pass the grizzley screens and to be fed through a cutter to the secondary screens or to the stocking ground.

The secondary screens are fed from a hopper distributing to three double-deck vibrating screens, the throughs of which are conveyed to a second stage comprising three more double-deck screens. Graded coke is conveyed to domestic bunkers with five 30-ton compartments for coke breeze and four sizes of nuts. These bunkers deliver graded coke either by vibrating feeders and debreezing screens to rail wagons, or by conveyor to the stocking ground or the boiler house hoppers. Run-of-oven or screened coke can be handled in and out of stock at 200 tons per hour. Coke for stocking out is conveyed to the feed hopper of an aerial ropeway system and alongside the delivery conveyor is a reclaiming conveyor fed from the ropeway through a buffer hopper.

In the main screen house there is a control desk with a mimic panel consisting of a geographic line diagram of the whole coke handling and screening plant with indicator lights to show the actual flow of coke. The required flows are chosen by selector switches and brought into operation by push buttons on the control desk.

By-Product Plant

Owing to lack of space on the old site, a new by-product plant was built on the new site to handle the gas from the new sixty-six-oven battery and from the rebuilt thirteen-oven and fourteen-oven batteries on the old site, the foul gas mains from the two latter joining the foul gas mains of the sixty-six oven battery at the inlet to the primary condensers. The new by-product plant thus receives the gas from the carbonisation of about 2000 tons of coal per day, leaving the old by-product plant to handle a slightly lower gas volume than before.

The old plant comprises primary condensers, exhausters, detarrer, ammonia scrubbers and benzole scrubbers; gas for heating the ovens on this site is taken from the outlet of the benzole scrubbers via two Askania governors. Surplus gas enters the outlet main of the new by-product plant. Liquor from the ammonia scrubbers is worked up in a concentrated ammonia liquor plant on the new site.

The new by-product plant is generally of orthodox design and comprises primary condensers, exhausters, detarrers, semi-direct saturators, direct secondary coolers and benzole scrubbers. At the point where gas from the old site is received an existing gasholder is connected to the main to act as a balance holder. This main divides into two branches, one of which delivers heating gas to the sixty-six oven battery via an Askania governor while the other delivers surplus gas to the final naphthalene washers. From the outlet of these washers the gas is again divided: about 4,000,000 cubic feet per day is pumped unpurified to Swinton and Mexborough for the Gas Board; the remainder is boosted through tower purifiers and returned to the compressors which deliver to the gas grid. A 750,000 cubic foot gasholder acts as a balance holder on the outlet of the purifiers. Provision is made for dilution of all surplus gas by producer gas, but the producers are not yet installed.

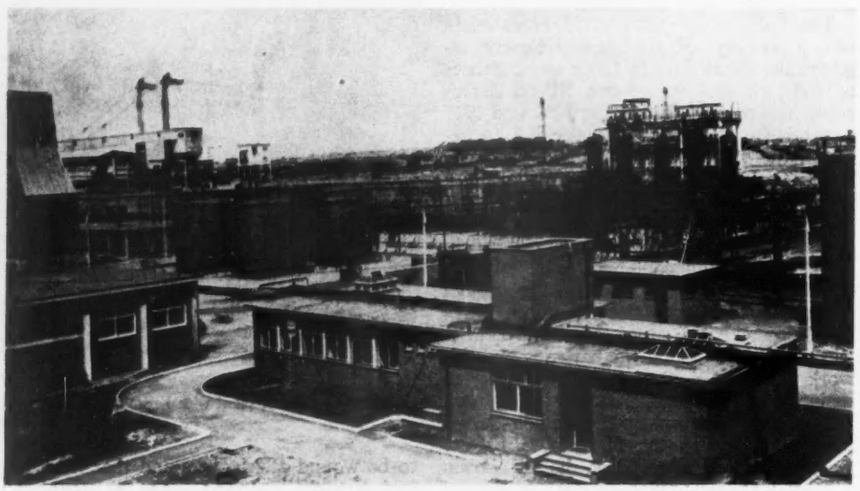
The four compressors which deliver to the gas grid are installed in a house with space for two more, and each has a capacity of 6,000,000 cubic feet per day. Of the four existing machines one is steam driven, one electrically driven, and two dual driven, the electric motors being housed in a separate motor room with drives through gas-tight glands in the wall. This driving arrangement enables varying gas loads to be handled with economy of steam and electricity and without need for using variable-speed motors. The compressed gas is cooled in indirect after-coolers, from which it passes straight to the grid. The unpurified gas supply to Swinton and Mexborough is taken off the inlet to the purifier boosters and passed through a Connersville meter to either of two compressors of 4,000,000 cubic feet per day capacity; one compressor has electric drive and the other dual drive, the motors being housed in the same motor room as those of the purifier gas compressors. Two indirect after-coolers are provided.

The crude benzole from the whole plant is recovered in three stills located on the old site with their oil heaters, columns, coolers and naphthalene trays. The crude spirit is pumped to storage tanks of a new refinery. This refinery can handle 15,000 gallons of crude spirit per day, which represents the whole of the crude produced at Manvers together with a million gallons a year of crude from other works.

The power station of the plant has two Parsons turbo-alternators, the turbines being back-pressure machines steamed by three Simon-Carves boilers with automatic control. The boilers are of tri-drum twin-circulation design. Each is equipped with superheater, desuperheater, economiser, single-grate mechanical stoker, and two gas burners in each side wall. The steaming conditions are steam pressure, 625 lb per square inch; steam temperature, 815 deg. Fah.; continuous maximum rating, 60,000 lb per hour, and continuous peak load, 70,000 lb per hour.

Two reducing valves reduce steam pressure from 650 lb to 160 lb per square inch and two spray desuperheaters reduce the steam at 160 lb per square inch to a temperature of 550 deg. Fah. These reducing valves and desuperheaters are used when the turbo-alternators are shut down. The boilers are arranged for firing by sandwich-fired coal and coke breeze or by coal or coke-oven gas, with provision for future firing by coal and tar fuel. The 550V main switchboard consists of one twelve-unit metalclad cubicle switchboard and, three 550V fuse distribution boards are also provided.

The construction of the plant presented a number of special problems, many of which arose from the necessity to maintain uninterrupted gas supplies to the Gas Board under existing commitments. This was achieved by careful planning of the starting and finishing dates of every stage of the work, but complications were caused by the fact that reconstruction of the existing oven batteries had been begun before the extension was settled. The new battery of seventeen compound ovens on the old site was built in order to maintain gas output during the successive reconstructions of the various existing ovens, and a bridge was used to span the fifteen-oven battery, and later the



Benzole refinery before the sixth fractionating column was erected

thirteen-oven and fourteen-oven blocks of the old thirty-oven battery, so that the charger car could continue to draw coal from the service bunker throughout the progress of the work.

Main Contractors for the Manvers Plant

Simon-Carves, Ltd., Stockport, coke ovens and by-products plant, boiler and power plant, benzole refinery, coal and coke handling plant, electro-detarrers; Parolle Electrical Plant Company, Ltd., Newcastle, boiler and power plant; W. C. Holmes and Co., Ltd., Huddersfield, gas purification plant; Gibbons Bros., Ltd., Dudley, gas dilution plant; J. M. Henderson and Co., Ltd., Aberdeen, coke stocking plant; Mitchell Engineering Company, Ltd., Peterborough, mechanical handling plant.

Failure of a 60MW Steam Turbo-Generator

By A. L. G. LINDLEY, M.I.Mech.E.,* and F. H. S. BROWN, B.Sc., M.I.Mech.E., M.I.E.E.†

No. III—(*Concluded from page 510, April 4*)

Details of investigations into the failure of a 60MW steam turbo-generator at Uskmouth power station on January 18, 1956, were given in a paper discussed at the Institution of Mechanical Engineers, London, on March 21, 1958. The paper showed that the catastrophe resulted from failure of the governor and emergency protective devices after the exciter had been inadvertently tripped; this failure was traced to the presence of black oxide of iron in the oil system and the way it built up on the working surfaces of pistons and cylinders. Overspeeding of at least 70 per cent followed, causing disintegration of the l.p. turbine and the generator. Abstracts from the paper are given here.

Investigations into Presence of Black Iron Oxide

EXAMINATION by X-ray diffraction and by the electron microscope, showed that the hard, shiny black deposit on the power piston and cylinder of the primary governing relay was almost pure magnetite (Fe_3O_4) in an extremely fine state of subdivision. The diameter of the individual particles was found to be between 0·02μ and 0·05μ, but when dispersed in oil and other liquids the particles were found to flocculate into soft aggregates. Similar examination of black pasty material from other control gear pistons and from sections of piping from the control system showed that this material was also very finely divided magnetite, but in these cases it was not compacted into a hard layer.

In all these samples no trace of ferrous oxide (FeO) was found. It was therefore most unlikely that the magnetite had been derived from mill scale, since the latter always contains a proportion of FeO so intimately mixed with the magnetite that it cannot be separated even after extremely fine grinding.

The results of a large number of trials, in test tubes, with various reagents acting on clean mild steel specimens proved that, under certain conditions, almost pure finely divided magnetite can be formed by two types of reagent. One is very dilute nitric acid, and the other a group of dilute aqueous solutions of alkali metal chlorides; the most important of the latter are dilute sodium chloride solutions, including, as might be expected, dilute sea water. Pure water and solutions of other salts and acids were found to produce the orange hydrated ferric oxide (rust), either pure or with only occasional traces of magnetite.

When examined under the electron microscope, the magnetite produced from dilute solutions of sodium chloride (NaCl) or from dilute sea water was found to be practically identical with that from the Uskmouth machine, but the magnetite formed in dilute nitric acid was of somewhat coarser particle size.

The experiments were then repeated on mild steel specimens coated with mill scale. With these specimens it was found that while dilute sea water or NaCl solutions produced magnetite as before, the nitric acid produced the orange hydrated ferric oxide. This was an important result because the piping in the control system of the Uskmouth machine had the usual residual internal coating of mill scale; this being so, the fact that the deposit on the piston was magnetite and not the orange compound was a further pointer against nitric acid being the active agent.

Next, studies were made of the action of sodium chloride and of natural and synthetic sea water over a large range of concentrations. These experiments showed that practically pure magnetite is formed both in solutions containing between about 0·5 and 0·05 per cent of NaCl and in sea water diluted with about 5–60 parts of pure water. At concentrations both higher and lower than these, less magnetite is formed and some orange hydrated ferric oxide is also produced, the proportion of the latter increasing the further the concentration departs from the above optimum range.

Since nitric acid had been ruled out by the mill scale experiments and since the optimum production of magnetite occurs at a fair degree of dilution of sodium chloride it appeared very probable that estuarine water was the active agent.

Minute quantities of the siliceous shells of both marine and fresh water diatoms were identified by microscopic examination of residues extracted from various parts of the control system of set 5. This evidence also points to the entry of estuary water into the oil system.

It is important to emphasise that optimum concentration will not alone ensure the production of pure, or almost pure, magnetite when mild steel specimens are placed in saline solution. Further essential conditions are that part of the specimen must emerge above the liquid and that the atmosphere above the solution must contain oxygen. The reason is that the formation of the magnetite from iron or steel in sodium chloride solutions depends on electrochemical action resulting from differential aeration. It will be seen later that the facts that air must be present above the liquid and that part of the metal must emerge above the air-liquid interface give important clues to the manner in which the magnetite was formed in the Uskmouth machine. Before discussing this, however, it is necessary to describe some further experiments.

It was found that the amount of the metal that emerges need only be very small, in fact, the emergence of only 1mm of metal above the air-liquid interface is sufficient to ensure the production of magnetite. This was shown by setting up two test tubes containing sodium chloride solution in the optimum concentration range. A mild steel strip was suspended vertically in each so that in one case the top of the strip emerged less than 1mm above the liquid while in the other tube the top of the strip was less than 1mm below the liquid surface. After a week or so the tube with the emergent strip became black with magnetite, while the other tube was orange with hydrated ferric oxide.

Additional studies were then made to determine the effect of turbine lubricating oil. First, the mild steel strips were coated with a thin layer of oil by dipping them in fresh turbine oil before suspension in the salt solution. The results showed that the thin layer of oil had no protective effect and, as before, magnetite and the orange compound were produced, respectively, in the emergent and immersed condition. If, however, a thick layer of oil was put on the top of the liquid, only the orange compound was produced, whether the strips were emergent or not. This was simply because the thick layer of oil greatly reduced the access of oxygen. Lastly, it was found that no magnetite was formed when the specimens were placed in emulsions of salt solution in turbine oil.

The investigations with strips emergent and totally immersed in salt solutions next led to a series of experiments which had an even closer bearing on the main problem. Two 5in lengths of 1in diameter mild steel pipe, of the type used in the lubricating and control systems and having an internal coating of mill scale, were sealed at the ends by waxed-on glass plates. Each pipe had a hole drilled in its side and both were set up horizontally with the holes uppermost. One of the two pipes had a glass tube waxed over the hole and was so completely filled with 0·25 per cent NaCl solution that the air-liquid interface occurred in the glass tube; this pipe thus corresponded to the completely immersed case of the previous experiments. Into the second pipe only quite a small amount of the same salt solution was introduced; it therefore corresponded to the previous emergent case, since now the metal emerged from the liquid into the air inside the pipe.

After standing for about two weeks, the pipes were shaken and their liquid contents poured out. It was found that the liquid from the second pipe, which contained only a little salt solution with air above it, was black with suspended magnetite.

The liquid from the other pipe, which had been kept full of solution, contained only a small amount of the orange product. The amount of the latter was only about one-tenth that of the magnetite, in spite of the much greater surface area of metal in contact with the solution.

These experiments thus showed that a little dilute salt solution in a pool at the bottom of a horizontal pipe containing air can produce magnetite, and, moreover, in quantity materially greater than the amount of orange hydrated ferric oxide formed when the pipe is so full of the solution that air is excluded.

Assuming slight contamination of the oil by a sodium chloride solution, there would

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be no tendency for magnetite to form when the set was in operation, since the salt solution would be present in suspension in the oil in the pipes which, apart from the drain pipes, would in any case be running full, that is, with no free air surface.

If, however, the bulk of the oil were drained from the system, as would be the case if the set were shut down, conditions extremely favourable to the production of magnetite would obtain. It is reasonable to expect that the saline water would then accumulate as pools in various places and that air would enter the system to replace the oil drained out. Then, since the metal surface of the pipe would emerge from the pools into the air space above, there would be all the necessary conditions for the rapid formation of magnetite, bearing in mind that neither thin layers of oil remaining inside the pipe nor the presence of mill scale on its internal surface would affect the result.

On restarting the machine, oil would be delivered by the main auxiliary pump to the distribution and pressure control box where part would pass to the bearings and thence to the tank, whilst the remainder would pressurise the piping up to the oil release valves. When these were depressed by the resetting of the emergency gear, oil would surge forward and fill the relay system, but, to begin with, only a small flow would return to the tank by leakage past pistons and pilot valves. As the set was loaded, all relay cylinders would accept a full charge of oil.

Any accumulation of magnetite which had formed in the pipes during shut-down would be collected at the head of the advancing streams of oil and, in the case of the oil to bearings, would return to the tank, where, on account of the volume of oil stored (3000 gallons) it would result in an insignificant concentration. In the case of the pipes leading to the relays, however, the accumulation of magnetite would be delivered to the operating cylinders and squeezed into the clearance spaces between pistons and cylinders, pilot valves and sleeves.

A mechanism by which a concentration of magnetite could be delivered to the relays having been established, the next logical step was to study the manner in which compaction could take place on working surfaces of pistons, &c.

In the first instance, small quantities of finely divided magnetite, produced from saline solution, were rubbed between surfaces of small blocks of metal and were found to compact very readily on the surfaces. Moreover, the compacted magnetite exhibited a highly specular reflecting surface similar to that of the material found on the piston of the primary governing relay of the Uskmouth machine.

In further experiments, a rig was constructed consisting of a small cast iron cylinder in which a cast iron piston 2in long by ½in diameter could be reciprocated at various speeds. Mixtures of finely divided magnetite (produced from saline solution) and oil were fed into the cylinder at various temperatures and pressures. No deposition of magnetite occurred as a result of injecting magnetite and oil alone, but when a small amount of water (1 per cent) was introduced under conditions which gave rise to an emulsion of water in oil containing the dispersed magnetite, hard layers of magnetite were found in streaks along the piston.

Further experiments demonstrated that if a dilute (0·05 to 0·5 per cent) sodium chloride solution containing magnetite was introduced with uncontaminated oil, magnetite compacted on the surface of the piston even when the magnetite in salt solution was added to the oil in drops. Microscopic examination of such suspensions and emulsions showed that the magnetitte particles in oil formed agglomerates 0·5μ to 5μ across. With water added to the suspension, magnetite agglomerates (1μ to 2μ) collected on the periphery of the water droplets which are 9μ to 15μ diameter. It appears, therefore, that the effect of the water when present as an emulsion is to concentrate the magnetite particles in the form of aggregates around the fine droplets of water in the emulsion.

It became clear from these experiments that the build-up of magnetite on working surfaces was associated with the existence of reciprocating motion. Thus, if an accumulation of magnetite were forced into the relays, the subsequent reciprocating motion of the pistons would cause compaction on the walls, and it is significant that the only components on which the magnetite was firmly compacted were the piston and cylinder of the primary governing relay, which generally oscillates continuously when the set is running on account of the normal slight disturbances from the governor spindle. The amount of oscillation of the other relays is usually comparatively insignificant except in the event of load changes, and in these cases the magnetite might be expected to form a greasy paste. This is fully consistent with the observed results.

It was thus established that contamination of oil by saline water resulted in the formation during shut-down periods of corrosion cells in the oil piping. In these cells, magnetite of very small particle size was formed, which ultimately caused failure of governing and emergency protective systems.

The means by which saline water entered the control system has not been established. Apart from the possibility of a slight leak in an oil cooler, the quantity involved need have been so small that accidental introduction into the oil system is not impossible.

A review of the operating history in the light of the results of the foregoing investigation now revealed highly significant features.

Operational History

It so happened that set 5 suffered an unusual amount of delay before it was commissioned and put into service.

The sequence of erection was such that the turbine was completed before the generator, and opportunity was taken to run the turbine on its own. After minor adjustments the machine was shut down and remained undisturbed for about nine weeks until erection of the generator was completed.

During the drying out of the generator, a certain amount of rough running was experienced which caused damage to the packings of the high-pressure rotor and necessitated its being returned to the maker's works. This resulted in a further shut-down of about six weeks, following which the generator was dried out afresh without incident and the set went into service.

There were two subsequent shut-downs of short duration, one on account of defects to the high-pressure heaters which were taken out of service and remained so until the accident, and one for examination of the governing gear, when what was thought to be "pipe scale" was removed from the power pistons operating the lower governing valves.

Apart from these two shut-downs the set had been in normal service for about eight weeks prior to the breakdown.

The investigations into the presence of black iron oxide in the oil circuit have revealed the significance of the shut-down periods in contributing to the formation of the oxide and have shown how it was carried forward into the relays when the set was restarted.

Examination of the history of the machine in the station log, and elsewhere, showed that there was, in fact, a progressive deterioration of governor performance during its brief operational life, and, in retrospect, after making allowances for differences in terminology and for a certain amount of confusion between cause and effect, it appears clear that references in the records to such things as "lack of response to motor speeder gear" and "pilot valve sticking" can, in fact, be readily explained on the hypothesis of a progressive build-up of black iron oxide on the power piston and cylinder walls of the primary governing relay.

Account of Metallurgical Investigations

The direction of the metallurgical work on the break-up of the low-pressure turbine and the generator rotors was influenced by the evidence presented from time to time by the main investigation. At first, a thorough survey was made of all fracture surfaces of ruptured rotating components for the presence of visible flaws which could have contributed to the failure of either rotor. Later, a more detailed examination was made of the mechanical properties and the metallurgical condition of such parts, where the type of fracture was considered to be of significance.

In the following brief summary of the results of tests made, many fractures are referred to as "brittle." This term is intended to be taken in its technical sense as describing the appearance of the fracture and does not imply that the material was defective.

Turbine Rotors.—Inspection of the fractures in the rotor shafts, both high-pressure and low-pressure, did not reveal any defect in the material which could have been an origin for the fractures. Fig. 4 [*ante*] shows the position of the main fractures in the low-pressure rotor.

Apart from the loss of blades, all the low-pressure wheels were intact with the exception of No. 6B, fragments of which were assembled by careful matching of fractured surfaces to obtain the build-up as shown in Fig. 5 [*ante*].

The probable process of break-up of this 2½ per cent chromium-molybdenum steel wheel had previously been described and despite the considerable plastic deformation associated with the fracture of the hub in the bore opposite the keyway, all the fractures were of a "brittle" type. Examination of these multiple fractures failed to reveal the presence of any flaw in the steel which may have served as a source of failure of the wheel.

In seeking a reason for the complete disruption of wheel 6B in comparison with the unbroken condition of wheel 6A, a comprehensive survey was made of the physical condition and the mechanical properties of the two forgings in the highly stressed region adjacent to the keyways.

Sulphur prints and macro-etching of sections cut from the hubs in these regions showed no abnormalities, but ultrasonic flaw detection and magnetic crack detection revealed the presence of a number of small hair-line cracks in the hub of wheel 6A which was intact, whereas no such flaws were found in the hub of wheel 6B, which had fractured. Thus, in this case the hair-line cracks appeared to have no deleterious effect on the performance of wheel 6A.

Impact-transition temperature curves for

each wheel were determined on tangential V-notched Charpy test pieces over the range of −20 deg. to +200 deg. Cent.

The tensile test results showed a uniformity throughout the hub sections and between the two wheels, the material specification being satisfied.

The Charpy impact values, although relatively low, were considered to be normal for this size and type of forging. Those taken throughout the hub sections tangentially with the notch parallel to the keyway indicated that the average for wheel 6A was higher than those for wheel 6B, although impact tests near the bore in both wheels were very similar.

As the running temperatures of wheels 6A and 6B were of the order of 25 deg. Cent., the results of the impact-transition temperature tests were given due consideration. The transition temperature for wheel 6B was found to be higher than that of 6A, the difference being of the order of 15 deg. to 50 deg. Cent. between the two wheels depending upon the method of assessment of the transition temperature.

It is clear that the two wheels had been operating at a temperature below the impact-transition temperature, and it must be accepted that their relatiye behaviour was consistent with the notched impact values. The difference in these values, however, was relatively small and it should not be concluded that it necessarily accounts for the fact that wheel 6B failed and 6A did not, particularly since the significance of notched impact value in relation to the susceptibility to rupture of disc forgings rotating at high speed has not yet been established, and it is not now possible to determine whether the two wheels were subjected to identical stressing conditions when the set overspeeded.

Generator Forging.—The 1 per cent nickel-chromium - molybdenum - vanadium steel generator rotor was extensively broken in pieces varying in size. All fractures had a " brittle" appearance.

When the driving end of the spindle was reconstructed, it was found to be appreciably bent, starting from the support ring end plate position and reaching a maximum at the reduced section adjacent to the wiper.

From an assembly of the broken parts, it was clear that in the break-up, a primary fracture had started at a shallow fatigue crack at the edge of a flute under the support ring, this spot corresponding to the start of the bend in the spindle. This fatigue crack was associated with fretting. From this origin, the crack proceeded to the axis of the rotor throughout its length.

All fractured surfaces were carefully cleaned and examined and no evidence of hair-line cracks or other obvious metallurgical defects were observed.

From one of the larger portions of the fractured rotor, tensile, bend and impact tests in longitudinal, tangential and radial positions were taken at the outside and also at points adjacent to the bore of the rotor. The mechanical properties were found to be as expected for a large forging of this type.

Impact-transition temperature curves were taken from the outside of the rotor body over the range −20 deg. to 200 deg. Cent. The transition temperature was estimated as being about 75 deg. to 80 deg. Cent., which was considered normal for this type of forging.

Sulphur printing of longitudinal and transverse sections indicated the segregation normal for the size of rotor. Magnetic crack detection and ultrasonic test showed no abnormalities. A detailed metallurgical examination was made of the fractured support rings, end plates and fan rings without revealing any grounds for considering any of these components to be defective.

In conclusion, it was decided that no evidence had been found to associate the break-up of the set with the metallurgical condition of the components of any of the rotors involved.

Mechanism of Breakdown

From the mass of evidence available in the damaged parts and knowledge of the circumstances immediately before and after the accident, it has been possible to build up a picture of the probable sequence of events and mechanism of breakdown.

Loss of control has been clearly established and deformation of certain components, particularly high-pressure wheel bores and the progressive shearing of high-pressure blade rivets, has indicated that the maximum speed attained was at least 70 per cent above normal and probably higher.

The time interval between the tripping of the exciter motor and the disintegration of the machine suggests that it accelerated at a rate corresponding to maintenance of full load steam flow.

There is much to suggest that the first component to fracture was the low-pressure wheel 6B adjacent to the generator. The main items of evidence supporting this hypothesis are : the driving key of wheel 6B was found intact, whereas those of all other low-pressure wheels were sheared ; an imprint of the keyway of wheel 5B was found on the region of shaft normally occupied by 6B and this could only have occurred if 5B had been free to move along the shaft ; there was a fracture of the low-pressure shaft in the middle plane of wheel 6B seating, whereas all other low-pressure shaft fractures were at changes of section between adjacent wheels ; all low-pressure wheel bores except 6B suffered deformation due to gyroscopic moments ; if fracture of 6B followed fracture of the shaft, deformation of the wheel bore would be expected, due to pressure from the shaft ; this is contrary to the observed facts.

The fact that a few blade forks were still attached to fragments of rim of 6B, but not to any other low-pressure wheel, coupled with lack of measurable circumferential strain on part of wheel 6B bore, is consistent with fracture of this wheel preceding general disintegration and would seem to suggest that the other rotating components attained a higher speed.

However, an overspeed of about 70 per cent would have been necessary for the blade roots to start to shear, and whilst the calculated overspeed for the onset of yield in the bore of wheel 6B is 63 per cent, it would be expected that a somewhat higher speed than this would be necessary to produce stretching measurable on the small region available. Therefore, it would appear that the difference between the maximum speeds attained by 6B and the other low-pressure wheels was not great.

In support is the fact that there was no major escape of steam, suggesting that by the time the fragments of wheel 6B penetrated the casing there was no longer the steam flow necessary to maintain the acceleration of the rotor system.

Wheel 6B broke up in a most unusual manner, the sudden radial fracture emanating from near the keyway, being followed by opening up to C-shape with time sufficient to allow considerable ductile deformation in the hub opposite the keyway. It is scarcely conceivable that an enormous out-of-balance force would not be applied to the low-pressure shaft during the early stages of this process and it seems most reasonable to deduce that this out-of-balance force, or the bending moment which would result from loss of support at the low-pressure turbine and generator inboard bearings following disintegration of the wheel and surrounding casing, or possibly a combination of both effects, was the initiating cause of total disintegration.

It seems very likely that the resultant transmission of bending moment to the generator rotor would trigger off the brittle fracture system, the small fatigue crack under the inboard end fan plate forming the selective starting point under the influence of bending stress. The mode of break-up of the generator rotor by rapid propagation of fracture of brittle type is not abnormal in view of the bulk of the forging and the very high level of centrifugal stress at 70 per cent overspeed.

The fatigue crack was not in a region of maximum centrifugal stress so that the fact of its being the starting point of brittle fracture is further evidence of some external action initiating fracture of the generator rotor.

The forcing of the shaft couplings over their back locating collars indicates the existence of a major axial thrust applied to the low-pressure shaft and the only likely source is the interaction of the major fragments of the bursting generator rotor. This phenomenon has been observed elsewhere (Schabtach, Fogleman, Rankin, and Winne, 1956).‡

Further buckling of the low-pressure shaft would follow from this axial force, bearing in mind its high rotational speed coupled with the fact that it would at this stage have been bent considerably by lateral forces.

During this phase of rapid buckling, the angular momentum of the high-pressure–low-pressure rotor system would be conserved and, since the moment of inertia about the axis of spin would be increased appreciably by the bowing, the angular velocity would decrease. The high-pressure rotor, which came to rest virtually in normal position, would thus be decelerated violently and this accounts for the torsional fracture of its shaft just under the high-pressure shaft gland.

The low-pressure wheels would, individually, attempt to preserve constant angular velocity about their original axis of rotation and thus tend to spin ahead of the shaft. The shearing of the wheel keys is consistent with this phenomenon, which also accounts for the coupling keys being unsheared, this being at first rather baffling, since the total torsional strength of all the low-pressure wheel keys was considerably in excess of that of the two couplings. The dynamic behaviour of the shaft system means that the torque which resisted the maintenance of constant angular momentum by the individual wheels and caused shearing of their keys was the result of the inertia forces at the wheel centres and the reaction at the bearings forming a couple.

The shearing of the keys left the individual wheels free to spin on the shaft with the possibility of major gyroscopic moments being developed, as borne out by the deformation of the wheel bores and damage to the seatings on the shaft.

The general damage to couplings is consistent with the transmission of a very high bending moment whose plane of action rotated in relation to the shafts. Such action

‡ Schabtach, C., Fogleman, E. L., Rankin, A. W., and Winne, D. H., 1956 *Trans. Amer. Soc. Mech. Engrs.*, Vol. 78, page 1567, " Report of the Investigation of Two Generator Rotor Fractures."

would result in the observed conical deformation of coupling bores and successive failure of bolts in tension.

The break-up of the low-pressure shaft, disintegration of low-pressure casing, and widespread scattering of the low-pressure wheels follows as a natural result of the foregoing processes, the natural tendency for the rapidly spinning wheels to resist angular change of axis of rotation being demonstrated by the damage to walls and roof of the turbine room, all of which corresponded to wheels being in substantially vertical planes when impact occurred.

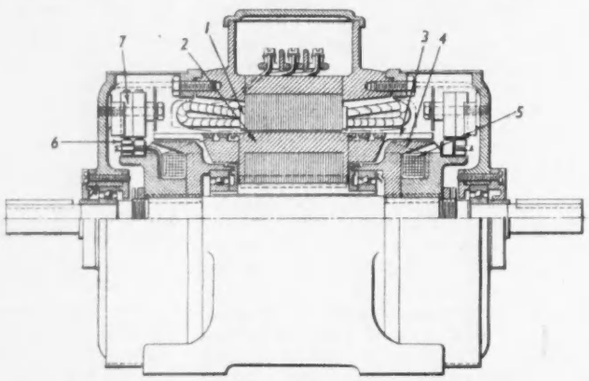
Combined A.C. Motor and Eddy-Current Coupling

THE "Varislip"* motor illustrated here is a combined a.c. motor and eddy-current coupling, designed and made by The British Thomson-Houston Company, Ltd., Rugby. By amalgamating the two components in a single casing, the company has achieved a considerable saving in space without sacrificing any of the advantages of the eddy-current coupling as a means of obtaining variable-speed output from a constant speed motor.

From Fig. 1 it can be seen that compact unit assembly has been produced by locating the eddy-current couplings within the stator end-windings in a space which does not normally contain active materials. Since the maximum diameter of coupling which can be fitted in this space is strictly limited, it is found to be necessary to use two couplings, each of which handles half the motor torque.

A conventional induction motor frame carries the stator core and windings. The illustration is of a foot-mounted horizontal machine, but it is possible to provide alternative methods of mounting to suit different applications.

The outer members of the eddy-current couplings are secured at each end of the squirrel-cage rotor, and this assembly is mounted upon the final output shaft with two ball bearings, so that the rotor is free to rotate at full motor speed when the couplings are unexcited.



1. Induction motor stator core and windings.
2. Induction motor cast aluminium rotor cage.
3. Eddy-current coupling, outer member.
4. Eddy-current coupling, field member
5. Eddy-current coupling, excitation coil.
6. Sliprings.
7. Brush boxes.

Fig. 1—Half-sectional view of the "Varislip" motor

Mounted on the final output shaft at either end of the squirrel-cage rotor are the two eddy-current field systems. Each of these field units is complete with an excitation coil fed through sliprings from brushes mounted in each end-shield.

When the motor stator is connected to a three-phase a.c. supply with no excitation current in the coupling windings, the motor rotor and coupling outer members run up to the full speed of 1500 r.p.m., but no torque is transmitted to the output shaft. By applying d.c. excitation current to the coupling field coils, torque is generated at the couplings and so transmitted to the output shaft. The output speed against a given torque will vary with excitation current flowing in the coupling windings. Speed variation is obtained by control of the excitation current.

Characteristics.—It is not possible to assign a definite horsepower rating to a "Varislip" motor. The three most important factors affecting the choice of motor size are :

(1) Peak torque output required.
(2) Permissible slip at the required peak torque.
(3) Temperature rise of the motor or coupling windings during the duty cycle required.

Characteristic curves for the No. 1 size "Varislip" are shown in Fig. 2. The full line curves show speed-torque characteristics for various values of coupling excitation current when the machine is cold. As the temperature of the machine increases there will be a reduction of output torque for a given excitation current until, at the maximum permissible temperature rise, the torque values obtained will be approximately 70 per cent of those shown in Fig. 2.

The dotted curves of Fig. 2 show the total losses in the motor for any load torque and output shaft speed. To keep the temperature rise of the machine within a safe maximum value, the following values of maximum loss with operating time from a cold start must be observed :

Operating time	Maximum loss
10 minutes	2200W
30 minutes	1000W
Continuous	500W

By using these figures in conjunction with the speed-torque curves, it is possible to check if this size of "Varislip" motor is suitable for the duty and duty-cycle of a particular application.

For example, the continuous rating at 1000 r.p.m. is limited, by heating from 500W loss, to a torque output of 4·5 lb-ft, which is equivalent to 0·86 h.p. at 1000 r.p.m. At 1000 r.p.m. the maximum torque rating of 6 lb-ft (1·14 h.p.) is limited by a maximum excitation current of 4A, with a time rating of about one hour intermittent. The maximum rating obtainable on a continuous basis is 5·3 lb-ft torque at 1090 r.p.m., which gives 1·1 h.p.

It should be appreciated that an eddy-current coupling is not a "torque converter." The torque demanded of the motor is equal to the torque exerted by the couplings on the output shaft, and the product of this torque and the slip speed is a measure of the eddy-current losses in the outer members of the eddy-current couplings.

Thus, if the "Varislip" is delivering 1 h.p. at 1000 r.p.m., the torque demanded of the motor is $\frac{5250\times1\cdot0}{1000}=5\cdot25$ lb-ft.

Since the synchronous speed of the four-pole induction motor is 1500 r.p.m., the horsepower transferred across the air-gap of the induction motor is $\frac{5\cdot25\times1500}{5250}=1\cdot5$ h.p.

The speed of the squirrel-cage rotor will be approximately 1430 r.p.m., so that the slip losses are $\frac{(1500-1430)\times5\cdot25}{5250}=0\cdot07$ h.p. in the squirrel-cage rotor and $\frac{(1430-1000)\times5\cdot25}{5250}$ $=1\cdot43$ h.p. in the outer members of the eddy-current couplings.

A second size of "Varislip" unit is being developed, and it will have a rating approximately two to three times the values given for No. 1 unit in Fig. 2.

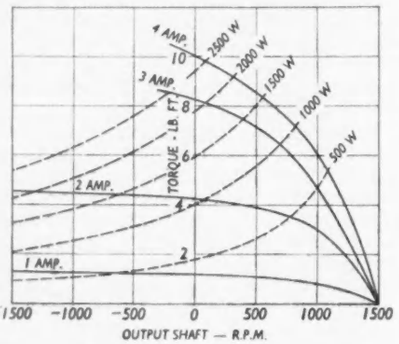


Fig. 2—Rating curves for "Varislip" No. 1 size motor. The full line curves show torque-speed characteristic with various coupling field currents. The dotted curves are contours of total loss in the machine

Applications.—The "Varislip" motor was developed by B.T.H. in conjunction with the Vaughan Crane Company, Ltd., for use in a variable-speed hoist block. More recently, units have been applied to the hoist and travel motions of overhead travelling cranes, where very fine control of speed and position are required. In a typical application to the crab of a Vaughan Crane "Vestac" Series II crane, the "Varislip" units are applied to the hoist and cross travel motions as follows.

The main hoist motion requires 15 h.p. in the hoisting direction, and this power is provided by a squirrel-cage motor and separately mounted eddy-current coupling. The "Varislip" motor is coupled through a common gearbox to provide a controllable "downwards" drive for light-hook lowering, and to apply an artificial load on the low-speed hoisting notches.

Simple and precise control of cross travel is obtained by the use of a pair of "Varislip" motors. The output shafts are coupled in tandem and the stator windings are connected so that the a.c. rotors run in opposite directions. Thus, the output shaft can be driven in either direction by energising the appropriate "Varislip" coupling field winding. In practice, to obtain the best possible characteristics, both field windings are excited all the time and the control rheostat simultaneously strengthens one field and reduces the other to cause rotation in the chosen direction.

There are many drives in industry which require variable speeds from a.c. supplies, and the potential of applications is considerable. Particular examples now being studied are connected with the fine control of feed drives on machine tools.

* The "Varislip" motor is covered by Patent No. 754,140, which is a joint patent of the B.T.H. Company, Ltd., and the Vaughan Crane Company, Ltd. "Varislip" is registered as a Trade Mark.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1

GENERAL REQUIREMENTS FOR SEAM WELDING IN MILD STEEL

No. 2937 : 1957. Price 4s. 6d.—This standard specifies general requirements for seam welding components made from mild steel sheet and strip under normal conditions of manufacture and service. It sets an upper limit of 0·32in (8mm) to the total added thickness of the components to be welded. Among the requirements dealt with are those for parent metal, edge conditions and form of components, the types of electrode to be used, routine tests and inspection.

Appendices provide notes on the welding plant as well as recommendations for minimum welding pressures—the pressures being related to sheet thicknesses, tread width and mean wheel diameters.

SHORTER REPORTS

Trends in Road Foundations

In spite of the absence of any considerable amount of new road construction—that is, until very recently—progress in constructional methods for road foundations has been very marked over the post-war period. The start of the Government's road programme has again attracted attention to this work. Present-day practice in constructing the road itself is due to be reviewed at the Institution of Highway Engineers' meeting to-day, when six papers are to be presented for discussion under the general title at the head of this article. Here are brief summaries of the six papers.

"*Bitumen Soil Stabilisation*," *by A. W. Jarman.*—Dry or wet mixing of soil with bitumen, according to climate, has been employed with success. For instance, in naturally wet sand or sand/gravel, special types of cutback bitumen in conjunction with the addition of hydrated lime were extensively used during the war for airfield construction in the U.K., and this process has been adopted in other countries as a cheap form of road base. Plastic soils of high clay content present problems which have not so far been solved, but those of medium plasticity have given good results, under favourable conditions, with cutback bitumens and asphaltic oils. In such cases the object of the treatment is to waterproof the soil at its optimum moisture content. Considerable research is in progress on the use of bitumen for soil stabilisation, and it is hoped that a process of more general applicability will emerge.

"*Coated Macadam*," *by R. Slater.*—Coated macadam as a foundation material, to receive "black top" surfacings, is discussed. Among the roads built with a coated macadam base are about 20 miles at the Isle of Grain oil refinery. The construction consisted of a 4in machine-laid sub-base of quarry spalls on a shallow fill of quarry waste and two 4in layers of ragstone-bitumen macadam, the 2½in graded aggregate being lightly coated with 200 pen. straight-run bitumen. The surface was blinded with fine cold asphalt at 150 square yards per ton before opening to traffic. These roads carried the heavy construction traffic for two or three years and on completion the final carriageway was provided by laying a regulating course of 1½in graded bitumen macadam to an average thickness of 2¾in and a wearing course of 1½in granite bitumen macadam blinded with sealing grit, with excellent results.

Coated macadam has been used more extensively, however, in building up foundations on realignments, widenings and superelevations on existing roads where thicknesses of up to 3ft have been laid. Experience has shown that good results are obtained on these works with binders of the consistency normally used for making coated macadam, but improved results, particularly stability immediately on cooling, are secured by using more viscous binders, e.g. 48 deg. to 55 deg. Cent. E.V.T. tar and 200 pen. bitumen. Nearly all the work has been done with the fairly open grading of basecourse mixture, but the trend is towards a mix with more fine aggregate, giving a lower void content after compaction, and this aspect forms one item of the co-operative research being carried out on this form of construction.

"*Concrete*," *by D. R. Sharp.*—Mr. Sharp gave examples of the very extensive use of concrete in road construction in many countries. He considered that in recent cases of tenders for road works, concrete had been "designed out" and not simply "priced out." This, he thought, was due to emphasis on initial cost rather than the true cost, which included maintenance, reconstruction and depreciation; these latter factors, he considered, altered the economic balance in favour of concrete. He concluded by commenting on certain physical characteristics of concrete—its colour, surface durability, speed of construction, skid-resisting and riding qualities. A high standard of riding quality was more difficult to achieve than with bituminous surfacing, but was well worth achieving because of its relative permanence.

"*Lean Mix Concrete Bases at Crawley*," *by M. Milne.*—In an area devoid of road-making materials, lean concrete has proved economical as a base for housing estate roads, which have proved to be soundly constructed. It is competitive in price with reinforced concrete, and suitable for many sites and weather conditions; further economies are possible with this method. The aggregate/cement ratios have been 14 : 1 throughout, and the water/cement ratio around 0·70. The minimum strength required is 900 lb per square inch at twenty-eight days.

"*Soil Cement Bases*," *by L. S. Blake.*—Recent achievements in this field are reviewed; since 1950, 300,000 square yards of soil cement bases have been built every year in Great Britain.

The most severe limitation to the use of soil cement is that certain soils must, at present, be regarded as unsuitable for stabilisation. Such soils include peat and certain other organic soils and also clays with liquid limits above 60 per cent and those with high sulphate contents. Organic soils are unsuitable because of the effect of organic matter on compaction and on the hydration of cement. Heavy clays cannot be broken down finely enough to permit intimate mixing; it is interesting to note, however, that before the British single-pass machine was developed, it was not considered practicable to stabilise clays with liquid limits in excess of 45 per cent. Research is continuing to determine the effects of organic matter, and this work may well result in a reduction in the number of soils hitherto regarded as uneconomical or impossible to stabilise.

On the other hand, many materials which, in their natural state, may be unsuitable for base construction, can be stabilised with comparatively small proportions of cement. Examples of these materials are quarry fines, limestone waste, certain shales, gravel pit washings, sands which are too fine for building, hoggin "as raised" and many others. It may often prove economical to incorporate a small proportion of cement into mechanically stable materials, such as "wet mix"; these materials rely upon good grading for their stability, but the addition of cement will provide improved stability and avoid the necessity for such close control of grading and moisture content.

A paddle mixer suitable for soil cement will soon be available in this country, and a single-pass machine with a mixing rotor capable of processing to a depth of 12in is now available.

"*Premixed Waterbound Macadam (Wet Mix)*," *by J. Drake.*—With the experience gained in Lancashire by the use of "wet mix" over the last few years, the conclusions reached are as follows:—

(1) As a base to a road in place of pitching, it fulfils the requirements. The dry densities obtained are approaching that of concrete, but density when using slag is dependent on the quality of the slag, i.e. whether mainly good sound slag or containing excess of honeycomb material.

(2) Suitable aggregates are slag, blue or white limestone (granite has not been used).

(3) The water content for mixing in the case of limestone is critical. For winter working and in inclement weather 2½ per cent to 3 per cent should be used; for summer working, not more than 4 per cent. Additional water, if required, can be applied by sprinklers from the roller.

(4) Segregation does occur but is mainly caused on loading into the lorry at the mixer rather than during transit.

(5) Back blinding behind the Barber-Greene is not normally necessary, rolling will effectively produce the required finish.

(6) It can be laid by hand successfully in places not accessible to the Barber-Greene, but has a tendency to segregate. It should be mechanically laid wherever possible.

(7) Speed of laying is dependent on supplies. Maximum laid by one machine in one day to date is 482 tons.

(8) Traffic can be allowed on new work immediately after rolling and scatter will not normally occur except under very rapid drying conditions.

(9) To prevent wet conditions affecting limestone "wet mix" the roller should be kept close up to the Barber-Greene to compact the material as soon as laid.

(10) The base course of tarmacadam or bitumen macadam can be laid immediately after the "wet mix" has been laid and rolled.

(11) The effect on the grading of the material due to rolling is less severe on limestone than slag, limestone showing an increase of 5 per cent due to crushing on the middle range of the stone size and slag 6 per cent, but in both cases this is not detrimental to stability.

(12) On trunk and class I roads, it should be laid 8in thick, in two 4in layers, on other roads 6in thick. For the Preston by-pass motorway, 9in is specified in two 4½in layers. (All these dimensions are after consolidation.)

Aircraft Power Plants

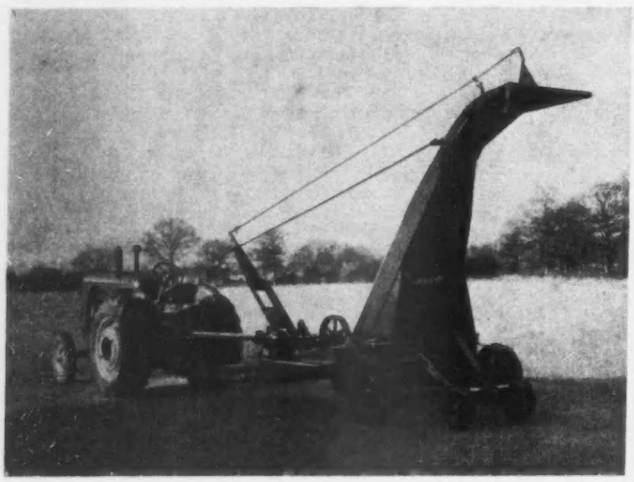
On a visit to the works of Bristol Aero-Engines, Ltd., we were able to examine the latest "Proteus" power plants, into which is built protection against both "wet" and "dry" ice. The heating of exposed surfaces by hot gas to prevent supercooled vapour freezing on them introduces the possibility of ice crystals in the air, which in suspension would pass harmlessly into the compressor, becoming wet and sticking to the duct walls. This could cause a mass of crystals to collect in the rearward-to-inward bend of the intake annulus which, when finally detached, might cause a flame-out. The velocity of air approaching this bend is of the order of 100ft per second; in the inward-to-forward bend inside the turbine intake ducts the velocity is, of course, much higher and ice cannot accumulate. The air jets which have been introduced as a remedy act simply by mechanically dislodging the ice; each is a flat jet about 2in wide, divided into two to strengthen the nozzle facing downstream and placed on the outer wall of the duct immediately forward of the inwards bend. There are four other jets, much smaller, close to each of the main engine mounting members, where they pass through the outer wall. The jets are supplied from the compressor tapping used for cabin pressurisation; in the rather hypothetical case of a flight conducted entirely in "dry" icing, the air bleed would involve a 2 per cent range penalty.

This engine was, of course, designed initially as an airline power plant, with reliability and economy taking precedence over minimum weight and size. While it would be expected that a turbine engine would have a particularly high reliability, it is noteworthy that this engine, which is the most powerful in airline service in the world, has increased its overhaul life faster than any other engine, so far as is known to the manufacturer. Entering service in February, 1957, at 500 hours, the engine was cleared for 1300 hours on March 19, 1958, 175,000 engine flying hours having intervened. During March, there were six premature removals in 16,000 hours, i.e. one every 2700 hours. There are so few turbines in airline service in the Western world that this performance can hardly be assessed other than by comparison with piston engines. While the "Centaurus," a sleeve-valve engine

of exceptional freedom from maintenance, is now cleared for 1700 hours between overhauls, and has averaged 4030 hours between premature removals over the last six years, the "Proteus" appears to be improving its overhaul life more rapidly than the smaller engine; both started with 500 hours' life, but the turbine went to 650 after 18,000 flying hours ("Centaurus" 600 after 17,400) and then to 1050 after 36,000 flying hours (1000 after 80,129).

Forage Harvesting Machine

THE conservation of green crops for cattle feeding is an important aspect of scientific farming. It has been practised on a relatively small scale in this country for a number of years, but in more recent times it has become increasingly prominent among farming techniques. Methods of drying grass and other green crops have been developed and a great deal of attention has been, and is being, given to silage making. This latter process of green fodder conservation has been practised, in a somewhat limited way, for quite a long time. In the years since the war, however, the development of silage making methods has been much more rapid. According to recognised authorities, there is still a great deal to be learned about the chemistry of silage making, but it is now a process that has been fully mechanised.



Lundell forage harvester, with bogie truck for use with heavy two-wheeled trailer when loading

It has been estimated that, at present, about 5,000,000 tons of silage are made annually in this country, a figure which, it is claimed, could be considerably increased. An important part of the equipment necessary for silage making is a machine which will cut, lacerate and load grass or other green crops. Various machines of this kind are now available in this country, one recently introduced being the Lundell forage harvester which is illustrated here. This machine is of American origin; it was brought to this country by two British farmers last year. A British company, Lundell (Great Britain), Ltd., was formed for developing the machine still further, and the model illustrated, which incorporates a direct-throw flail system, is now in full production for the company by Steels Engineering Products, Ltd., Crown Works, Sunderland. During a recent visit to Sunderland we inspected the production line and had an opportunity to examine the machine.

The Lundell harvester is offset to the tractor which operates it, so that there is no trampling of the crop prior to chopping. The principal component of the harvester is the rotor which carries twenty-eight swinging flails, made of hardened steel and independently secured by specially designed bushes and nuts and bolts. The width of cut normally taken by the harvester is 4ft 10in. The drive from the tractor is taken by a universally-jointed power take-off shaft, and is transmitted through bevel gearing. From the gearbox the drive is transmitted to the rotor by a main shaft, pulley wheels and vee belts. The larger of two pulleys is fitted to this main shaft in two self-aligning bearings housed in plummer blocks which are bolted to the main frame of the harvester. The smaller pulley is carried by the rotor which is a dynamically balanced unit, supported at each end by a self-aligning bearing. The tractor power required for driving the harvester is 35 h.p. upwards, the minimum speed of the flail rotor being 1500 r.p.m.

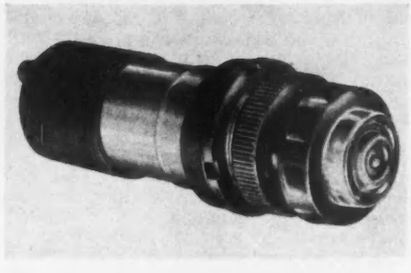
The machine is assembled on a fabricated steel main frame to the underside of which are bolted skid runners to prevent the machine sticking into the ground should either of the two pneumatic-tyred wheels enter a rut. An adjustable draught plate located behind the rotor controls the air intake to the flails and, in front of the rotor, there is an adjustable shear plate to control laceration of the crop. The delivery chute is made up of sheet steel sections, the top outlet being offset to one side. The spout at the top end of the chute can be turned backwards or sideways by means of a worm and quadrant controlled from a position within comfortable reach of the tractor driver, and at the top of the spout there is a spring-loaded hinged flap which can be moved up or down as desired by a control rope.

As well as cutting and lacerating forage crops, the harvester can be used for picking up wilted material from a swath, and for such tasks as leaf clearing in parks. The latest development is a hammer mill conversion unit, which includes an adjustable screen for dividing the rotor. On one half of the rotor the flails remain with their cutting knives attached and on the other half the flails are replaced by grinding hammers. A cyclone attached to the end of the delivery chute completes the conversion unit. A hopper is attached at the base of the machine for receiving the grain to be ground.

Press-to-Test Warning Lamp

THE latest addition to the range of electrical components made by Dowty Nucleonics, Ltd., Brockhampton Park, Andoversford, Glos, is a compact warning lamp incorporating built-in facilities for dimming and lamp filament checking. Equally suitable for industrial or aircraft use, the lamp is interchangeable with earlier electrical and electro-magnetic indicators, can be installed from the front of the mounting panel, and requires little space, its $\frac{11}{16}$in overall diameter allowing a minimum centre-to-centre distance of $\frac{7}{8}$in.

When used as a "normally off" warning indicator the lamp filament can be checked simply by pressing the transparent plastic lens, lighting the lamp through auxiliary contacts. The small replaceable lamps are available for 6V, 12V or 28V working, rated at 1W, and can be rapidly changed by unscrewing the front section of the unit.



This 1W warning amp of $\frac{11}{16}$in overall diameter is panel mounted by the castellated ring and washer. The lamp can be tested by pressing the housing

The warning lamp is available with or without variable dimming which adjusts the amount of light transmitted through the lens to suit the ambient lighting conditions. The adjustment is made simply by rotating the lens bezel through 90 deg. Red, green, amber, blue and clear lenses are available, each corrugated to spread the light and to provide a non-slip surface.

The three screw terminals at the rear of the unit are protected by a rubber cover with individual cable holes. Internal seals effectively reduce the ingress of moisture and dirt. The lamp, it is stated, can be used industrially at ambient temperatures up to 50 deg. Cent.

Concreting With Colloidal Grout

CONCRETING with colloidal grout is a well-established process, and there are a number of proprietary methods in use for the preparation of the grout. One such method, which has been widely used in the United States, is known as "Prepakt" concrete; the agent for this system in Great Britain is now Millars Machinery Company, Ltd:, Pinners Hall, London, E.C.2.

The "Prepakt" system utilises a chemical admixture to impart the colloidal properties to the grout. It is known as an "intrusion aid," and its functions are stated to be, first, to give the uniformity and, hence, resistance to segregation, characteristic of colloidal solutions; secondly, to decrease the viscosity and internal friction and, therefore, increase the penetrability of the grout; thirdly, to reduce the quantity of mixing water needed; fourthly, to retard the initial stiffening of the grout, and fifthly, to counteract the setting shrinkage of the cement and produce an expansion by the generation of tiny gas bubbles.

Plant for the preparation of colloidal grout on a site where repair of bridge piers, involving relatively small quantities of grout and concrete, is in progress

The grout mixture is also noteworthy for the use of fly ash. In fact, any pozzolanic material complying with certain specifications is stipulated, and in American practice this material is referred to as "Alfesil"; under British conditions, however, fly ash will be used. Its function, apart from economy (by replacing cement, there is a direct reduction in cost) is to improve penetrability, to retard the rate of stiffening to some extent, and to enhance strength and impermeability of the concrete at later ages, at the expense of strength at early ages. The grout "mix"

therefore comprises cement, fly ash, "intrusion aid" to about 1 per cent by weight of the cement and fly ash, fine sand (practically all the sand passes a No. 16 sieve) and water.

The concrete made by this method is, of course, gap graded, and the coarse aggregate is first placed in position in the forms. The minimum size for the coarse aggregate is stated to be ¾in. The voids in the coarse aggregate are generally between 33 and 42 per cent, and grout is introduced to fill them. The mixtures used generally vary between the following limits :—9 : 1 : 6 parts respectively by weight of cement, "Alfesil" and sand for a concrete for prestressed work with 12,000 lb per square inch ultimate compressive strength, to corresponding proportions of 1 : 1·6 : 5 for mass concrete for the "hearting" of dams giving 2500 lb per square inch compressive strength or less.

Apart from its application to normal concreting, advantages are claimed for the use of this system—and, indeed, of colloidal grout generally—in various special cases. For instance, concreting under water is feasible, since the colloidal grout will not mix with water and will thus displace it from the coarse aggregate. Repair of damaged structures is also cited, where the penetrability of the grout is of advantage, and the bond between old work and new is claimed to be very good. In the illustration we show a typical plant set-up on a job of this kind, where bridge piers were being repaired by encasing them with grouted concrete, and grouting the old work. The mixer is a paddle machine of 2·6 cubic feet capacity. Materials for the grout are volume-batched and mixed for two minutes. They are then discharged to the agitator shown in front of the mixer, first into the circular screen at the top, which retains any coarse matter, and thence into the trough of the agitator, where the grout is stirred by paddles. In the foreground is the grout pump; pressures up to 30 lb or 40 lb per square inch are generally used for work of this kind. Apparatus for laboratory and site tests with the "Prepakt" system has been largely standardised. For instance, the "flow factor" of the grout is the time in seconds which a given quantity of grout takes to flow out of a standard funnel. There is also a consistency meter which measures the "consistency factor" of the grout. For a full account of testing and properties, the paper "Composition and Properties of 'Prepakt' Concrete," by R. E. Davis and M. Polivka, presented at the R.I.L.E.M. international colloquium on injected concretes, held at Madrid, October 8, 1957, should be consulted.

Heavy Beam Testing Machine

We illustrate a beam testing machine of 200 tons capacity which has been installed at the Proving House of Lloyds British Testing Company, Ltd., at Low Walker, Newcastle upon Tyne: this machine was designed by J. Samuel White and Co., Ltd., of Cowes, in conjunction with the Principal Superintendent of the Proving House. It tests beams up to 39ft long and 5ft wide with a maximum loading width of 4ft; on it beams can be tested at extreme fibres and at the neutral axis—maximum loading width 3ft.

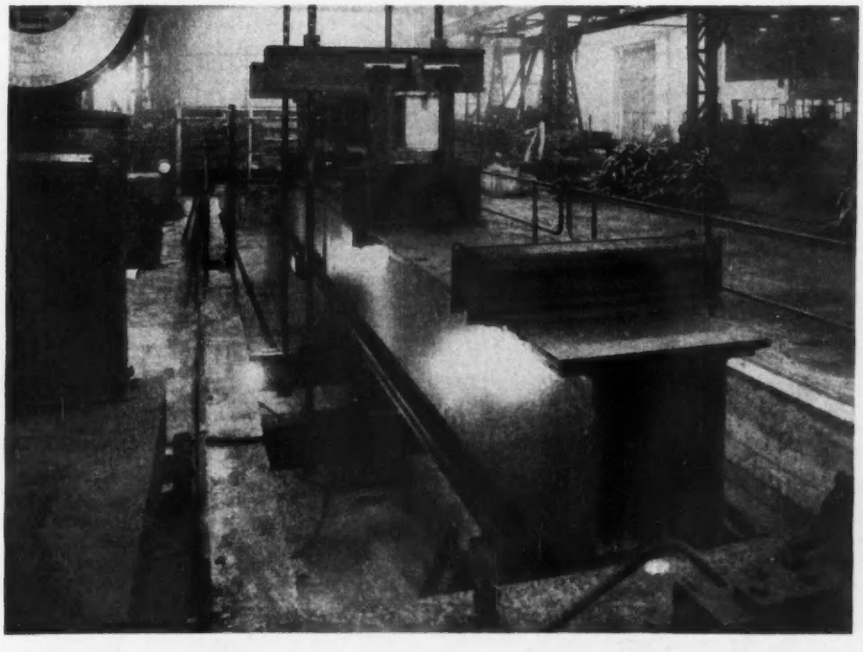
The basis of the machine is a massive main loading beam which is supported at one end by a hinged pivot and at the other by a hinged and sliding pivot. The main loading beam is fabricated from two 40in by 12in I-section broad flange joists with 1in thick plates welded to the top and bottom flanges to form a box girder. The overall length of this beam is 46ft 6in and its weight approximately 15½ tons. Test loads are applied to the beam under test by two 100-ton hydraulic jacks supplied by a variable delivery pump having a maximum working pressure of 6000 lb per square inch.

The jacks are mounted on cast steel bolsters attached to the underside of the main loading beam. These bolsters are suspended on wheels running on the upper side of the lower flange, so that the specimen can be loaded at any point in its length. When the jacks have been positioned the bolsters are clamped to the underside of the main beam.

The jacks transmit their load to lower cross beams lying at right angles to the main beam, through hydraulic capsules which give a direct reading in tons, on open scale gauges, of the load applied to the specimen beam by the jacks. These lower cross beams are slotted at each end to accommodate tension bars which pass upwards and through similarly slotted upper cross beams, the undersides of which rest on the beam under test.

For testing beams at the neutral axis special trunnions are mounted on the main loading beam and on the underside of the top cross beam, and these trunnions engage with pins attached at the neutral axis of the specimen beam.

This type of machine has the advantage that the foundations consist only of two pads, one under each end of the main loading beam, to take the pivoted supports. The foundations have only to take the dead weight of the machine, about 30 tons without the specimen beam. A pit is provided under the main beam so that the upper face of the main beam can be kept at floor level.

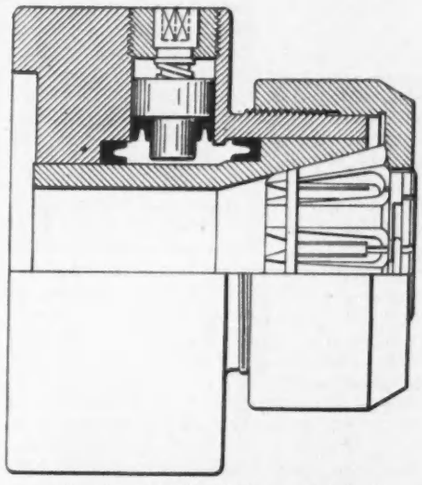


Beam testing machine of 200 tons capacity for beams up to 39ft long and 5ft wide, with a maximum loading width of 4ft

Wide Working Range Collets

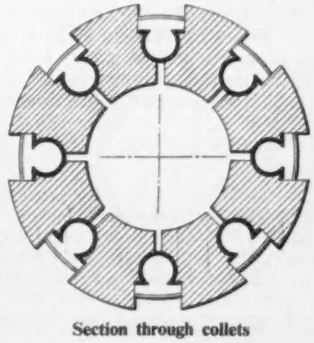
There will be put into production this year by Crawford Collets, Ltd., Witney, Oxfordshire, a series of "Multibore" collets which have a working range of ¼in on square or round objects and of a spanner interval on hexagons, e.g. from 0·720in A/F to 0·820in A/F. The introduction of such collets is expected to result in vastly smaller numbers of different collets being catalogued and stored in machine shops. It is a dead length device, and the jaws remain parallel throughout the working range.

While such collets can be used in certain existing automatic lathes, the makers have evolved a



Section through hydraulically operated chuck

hydraulic chuck to operate them. The segments of the collet are closed together by advancing a female cone over them, and the cone is moved by hydraulic pressure generated by a simple screw jack. It is claimed that the grip of the chuck is exceptionally strong, or that the effort is remarkably light.. The outer faces of the sectors are not completely conical, but the edges are relieved in such a way that as the collets



Section through collets

close, transferring the contact with the surrounding cone toward the edges of the sectors, the inner faces remain parallel. The springs separating the sectors are basically cylinders split along a generator, and hence they assist in keeping the parts aligned when the chuck is open. The retaining rings holding the sectors have a stepped gap so that no spring can escape, and the step is so much longer than the overlap that a spring entering the step does not jam the ring.

The collets can be used to hold very short workpieces. For this application the frustum of a cone is mounted on an adjusting screw behind the collets, and set so that the diameter corresponding to the work is opposite the inner ends of the jaws, which are therefore restrained when the work is gripped.

No performance figures for concentricity are at present available, but the claim is made that this system of chucking is highly resistant to dirt fed in with the bar stock, and that the collets can readily be removed and washed in paraffin. Sizes to grip up to 2in diameter will be available.

Industrial and Labour Notes

Steel Prospects

Every year, the United Steel Companies, Ltd., presents a report to its employees which is entitled *Review of Progress*. The latest one, which has just been published, surveys the group's activities during 1957, and has something to say about the prospects for the current year.

In this section of the report it is pointed out that steel is now in better supply in world markets and that export prices have fallen a good deal since last year. The reason, it is remarked, is curious. In the U.S.A. orders have fallen : steel output has been running at 80 per cent of capacity for some time and occasionally the operating rate has been even lower. In the United Kingdom, orders for steel have been maintained but capacity has at last caught up. In fact, the report says, more steel could have been produced during 1957, but circumstances arose towards the end of the year which made it necessary to close some uneconomic steelmaking plant in South Wales. During the post-war years of steel scarcity, both the U.S.A. and this country, which are not regularly large importers of finished steel products, have been importing unusually large quantities from the Continent. This, the report comments, they are now ceasing to do, so that France, Belgium and Germany have lost export orders and competition has increased for the regular import business in Africa, South America and Asia.

These difficulties, the report adds, which have already had their effect on the other main steelmaking countries of the world, are beginning to affect the British iron and steel industry. Tinplate and part of the tube trade are depressed. The report goes on to say that there is, undoubtedly, now some idle capacity in the building and construction trades which will continue to affect business in such steel products as sections and reinforcing bars. But, fortunately, the report goes on, there is something on the credit side. Most of the industries which buy British steel are flourishing ; shipbuilding is doing well despite the drastic fall in freights and the motor-car industry is so far defeating all the prophets of woe. The railway modernisation programme has been retarded to some extent, but track-laying is to go on as before so that the demand for rails will continue. Defence expenditure has been cut, but without serious effect on the British steel industry.

Royal Ordnance Factories

Before the House of Commons rose for the Easter recess last week, the Minister of Supply, Mr. Aubrey Jones, was questioned about the Royal Ordnance Factories. He was asked to what extent the " run down " of the factories had caused unemployment ; to what extent his department had helped to find established workers other employment, and whether he anticipated " any expansion from the present position in using dormant capacity for the making of newer types of weapons and other suitable production."

In his reply, the Minister said that the effect on employment of the slowing down in the ordnance factories had been only marginal. All the established employees had a right to continued employment in the Government service, and every possible effort was being made to transfer them to the establishments of their choice. He hoped that the ordnance factories would play an ever-increasing part in work on the newer kinds of weapons, though that could not be expected to make up for the " run down " in other requirements.

Training Allowances

The Minister of Labour has announced a modification of the training allowances scheme so that boys and girls are now able to receive financial assistance to take training in employment obtained in areas other than where they live, if necessary, in competition with local boys and girls. This assistance is available only for training in employment obtained through the Youth Employment Service. The scheme for giving financial help for boys and girls to receive training for skilled industrial occupations has operated since 1947, though it has been modified from time to time to meet changed circumstances. The scheme is restricted to assisting young people for whom no suitable facilities are available in their home areas.

Export Aids

Speaking at the recent annual luncheon of the British Compressed Air Society, the Parliamentary Secretary to the Board of Trade, Mr. F. J. Erroll, said that the Board had been making a general review of export arrangements. There were a number of ways in which the Board of Trade could help exporters ; some of them might appear to be obvious, though, Mr. Erroll commented, the obvious was often precisely the easiest to overlook.

He went on to mention such details as language. English, he said, was, of course, an international language of commerce, but by no means did all customers speak, read and still less write it. Worse still, Mr. Erroll continued, exporters might have customers who appeared, but only appeared, to understand English ; a re-examination of the facilities for correspondence and for the provision of catalogues and service literature in the language of the customer was of the highest importance. But he added a word of warning about the " disastrously comic effect " which could follow from mistakes in translation. There was also the question of market review, including such matters as the total size of a market for a particular product ; up-to-date and adequate information about the main users of the product ; the strong and weak points about competitors, and whether an exporter's share of a market was rising or falling. All that, Mr. Erroll said, might sound like stressing the obvious. But he felt sure there were few whose information and records were really impeccable in all those respects. On many of them, the export services branch of the Board of Trade in London and the Board's overseas representatives were able to help. They could assist exporters to assemble what he considered to be the basic facts about overseas markets.

India's Engineering Industry

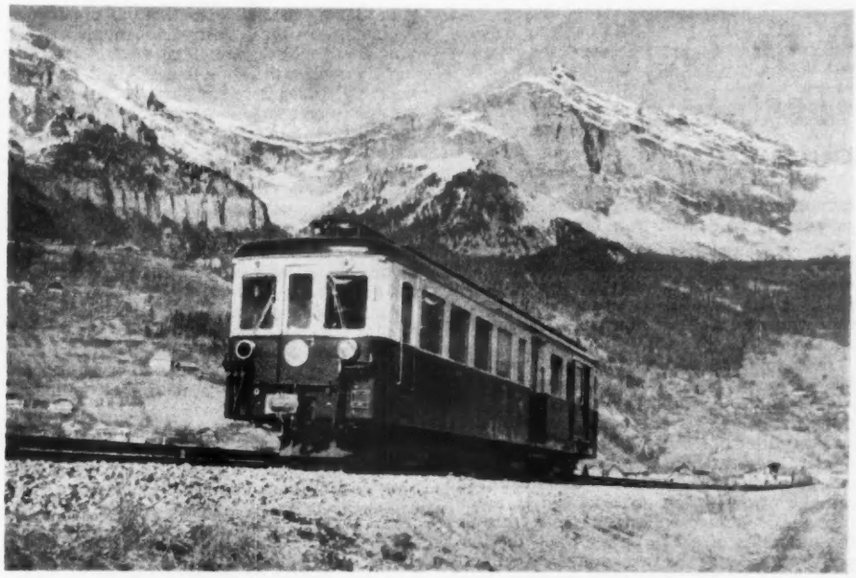
In his presidential address to the Indian Engineering Association on March 28, Mr. K. J. Cleetus said that the overall picture of the healthy progress of India's engineering industry in 1957 concealed certain dangers and weak points in particular sectors. If these went unchecked, they might easily lead to serious dislocation in production and to unemployment. Mr. Cleetus commented on the decline in production of electric motors, motor-cars, bicycles and other items in the second half of last year. The fall in the level of bank advances to the iron and steel and engineering industries from October, 1957, onwards, he said, provided confirmation that production was slowing down as a consequence of acute raw material shortages. This fall in advances, he added, was in marked contrast to the progressive increase from 1953 to 1956, extending even up to the first half of 1957.

Mr. Cleetus went on to say that the outlook for raw materials, particularly steel, during the current year was causing grave concern and the partial closure of many engineering works was becoming inevitable and imminent. One hesitated, he continued, to contemplate the serious consequences that a shortage of steel would produce in the Calcutta area, where the employment situation in the engineering industry was deteriorating slowly and steadily. Mr. Cleetus thought that the West Bengal and Union governments especially should heed the warning signals and take timely action so that the unpleasant consequences of partial and even complete closure of engineering establishments might be avoided. But, taken as a whole, Mr. Cleetus observed, the engineering industries had made very satisfactory progress during 1957. In the first ten months the index of production (1951=100) had risen to 236·5, compared with 219 in 1956 and 183·3 in 1955. Since 1953, he added, the general and electrical engineering industries had more than doubled their output.

Nevertheless, Mr. Cleetus urged, there was no economic future for India if the country hung on to outmoded techniques and methods of production. Mechanisation and rationalisation, he said, might result in temporary dislocations here and there, but these were " inescapable growing pains." Although many firms had succeeded in removing the heavy deficiency of machinery renewals and replacement, the high costs obtaining at present were thwarting all efforts to keep abreast of technological progress.

Middle East Industrial Projects Corporation

The Federation of British Industries has announced the formation recently of an international organisation known as MIDEC S.A. (Middle East Industrial Projects Corporation). Its object will be to further the development of industrial projects in the Middle East in conjunction with Arab and other local interests. The registered offices of the organisation are at Rue Aldringer 14, Luxembourg, and there are branches at The Hague and Beirut. The total initial share capital is 1,000,000 Swiss francs, the countries at present participating being Belgium, Canada, Denmark, France, Western Germany, Holland, Italy, Norway, the United Kingdom, Sweden, Switzerland, and the U.S.A. The shares in MIDEC S.A. allotted to the United Kingdom have been taken up by a banking group (three companies), a contracting group (two companies), and a manufacturing group (nine companies).



New train sets for the St. Gervais-Vallorcine line are to consist of two motor carriages like the one shown here, and one coach. Each motor carriage develops 545 h.p. Operation is on 800V, d.c., which is obtained from a third rail

Train Sets for the St. Gervais-Chamonix-Vallorcine Line

The French Railways have recently taken delivery of the first unit of four train sets they have ordered for their electrified metre-gauge line running through the Chamonix valley between St. Gervais the terminus of the main line from Paris and Vallorcine on the Swiss Frontier. This line uses 800V d.c. collected from a lateral third rail.

This unit is one of the motor carriages weighing 38 tonnes with a continuous rating of 545 h.p., and its trials before being put into service have already begun.

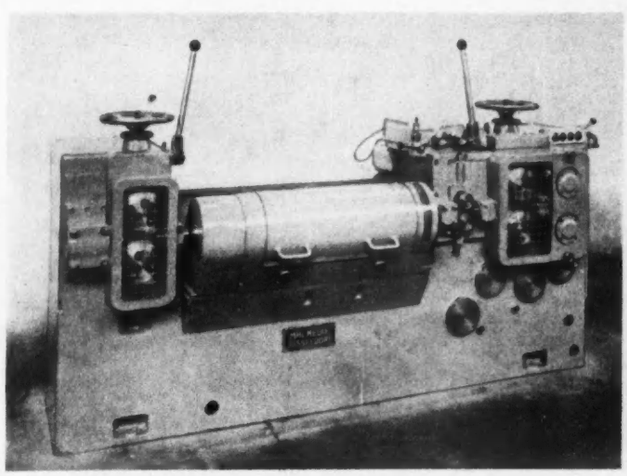
The train sets, each of which is composed of two motor carriages with a trailer carriage coupled between, will replace the present rolling stock, which has been in service on this line since it was opened in 1901. At that time, it ran between St. Gervais and Chamonix only, and it was not until 1907 that it was extended from Chamonix to Vallorcine to connect there with the Martigny–Chatelard line in Switzerland, which, in turn, gives connections at Martigny with trains running on the Simplon tunnel route.

The introduction of the new rolling stock will make it possible to improve the services ; for instance, the duration of the journey, particularly between St. Gervais and Chamonix, will be greatly reduced thanks to the power of the motors and the modern methods of braking. These are of particular importance on a line which has the distinction of having the heaviest gradients in Europe—9 in 100—to be tackled by simple adhesion traction without recourse to a rack.

During the period of summer service each set can convey 244 passengers (143 seated and 101 standing), while during the winter months 229 passengers (136 seated and 93 standing) can be carried. Each carriage has automatic couplings, enabling the composition of the set to be easily varied so as to cope with daily or seasonal traffic fluctuations. Finally, special care has been given to the interior fittings—comfortable seats, pleasant decor, wide opening windows—in order to provide passengers using this essentially tourist line with every comfort at all seasons. During the winter, detachable ski holders will be provided on the entrance platforms and in the luggage compartment.

Wire Straightening and Cutting-Off Machine

We have received details of a machine for straightening and cutting-off wires, made by Malmedie and Co., Düsseldorf (agents, Stuart Davis, Ltd., Much Park Street, Coventry). The capacity of the model " WRM " ranges from a wire diameter of 0·393in to 0·787in. The machine is stated to be eminently suitable for straightening and cutting steel rod with a maximum tensile strength of 35 tons per square inch. The wire runs from the coil into the infeed rollers where rough prestraightening takes place, and is then gripped by the pull-out rollers just in front of the cutting-off mechanism. The cutters are housed in two counter-rotating cutter bodies. The cutting operation is regulated by an electro-magnetic clutch actuated through a cam. The controlling impulse is given through the length measuring device, which is infinitely variable over the entire cutting range of 9ft minimum to 64ft maximum length. The measuring rollers which are in contact with the wire are housed between the straightening spinner and the pull-out rollers.



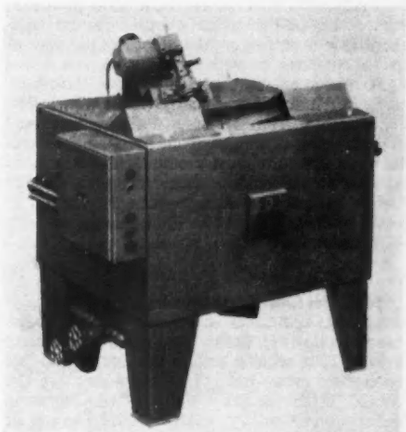
This straightening and cutting-off machine processes wire of $^{25}/_{64}$in to $^{25}/_{32}$in diameter at up to 400ft per minute

The straightening is carried out on the rotating spinner principle, and rotor and main drive have separate motors of 25 h.p., 3000 r.p.m., and 20 h.p., 1500 r.p.m., respectively, individually controlled by push-button. The machine is entirely self-contained and lubrication is through centralised pump. Instead of being fitted with a rotating spinner, the machine can be equipped with horizontal and vertical straightening rolls. It can also be fitted with a bundling bench to suit the lengths of cut rod. Straightening speeds are 200ft, 300ft and 400ft per minute.

Cleaning Plant for Ball and Roller Bearings

Another application for ultrasonic cleaning, the range of which is rapidly increasing, has been found in the ball and roller bearing industry. Schoeller and Co., of Frankfurt/Main (U.K. representative : Roto-Finish, Ltd., Mark Road, Hemel Hempstead, Herts), has recently supplied automatic ultrasonic cleaning machines for cleaning assembled ball and roller bearing races.

These machines, one of which is shown in the accompanying illustration, can, it is stated, clean



Automatic ultrasonic cleaning plant for the cleaning of assembled ball and roller bearing races

5000 bearing assemblies of 30mm diameter per eight-hour shift. They can be set for cleaning bearing races in sizes from 25mm to 75mm in diameter, and similar machines can be supplied for other sizes.

The machines have two ultrasonic cleaning stages, and a device for revolving the bearing races during the cleaning operation. The cleaning fluid used is petroleum ; filtering apparatus and a circulation pump are built in.

Annual Conference on High Energy Nuclear Physics

More than 200 scientists from twenty-six nations have been invited to participate in the 1958 Annual International Conference on High Energy Physics organised by the European Organisation for Nuclear Research (C.E.R.N.) in Geneva, from June 30 to July 5.

This meeting continues a series of seven annual conferences on high energy nuclear physics previously held at Rochester, N.Y. C.E.R.N. last acted as host to physicists from all parts of the world at the symposium on high energy accelerators and pion physics held in Geneva in the summer of 1956.

During ten plenary sessions at the Auditorium of the Physics Institute of the University of Geneva, the physicists will exchange information on the fundamental properties of the atomic nucleus. Papers will be presented on nucleon structure ; the nucleon and its interactions with pions, photons, nucleons and anti-nucleons ; fundamental theoretical ideas ; strange particle production and interaction ; invariance principles and selection rules, and weak interactions.

Underground Nuclear Detonation at Nevada Test Site

BY OUR AMERICAN EDITOR

THE U.S. Atomic Energy Commission disclosed last month that a deep underground nuclear shot, "Rainier," was detonated on Thursday, September 19, 1957, at the Nevada Test Site. The shot device was one with a known yield of 1·7 kilotons, designed by the Los Alamos Scientific Laboratory. It was placed in a chamber 6ft by 6ft by 7ft at the end of a tunnel approximately 1900ft long that had been bored horizontally into the side of a volcanic rock mesa near the north-west corner of the Nevada Test Site. The shot chamber was situated about 900ft under the mesa top, and about 800ft from the steeply sloping hillside.

The firing of the Rainier shot was controlled primarily from a special forward control point installed in an existing timing station about 10 miles from the tunnel mouth. Members of the Nevada Test Organisation viewed the effects of the detonation from a forward area about 2½ miles south of the tunnel mouth. Some spectators saw a ripple on the side of the mesa as the shock wave moved upward. A few felt a slight movement in the earth under their feet, but most felt nothing. Clearly visible were spurts of dust rising from the side of the mesa caused by rock being dislodged from the visible side of the mesa crown. Dust created as rocks rolled down the steep hillside caused a loose cloud which slowly dissipated. Radiological surveys conducted after the shot showed that no radioactivity was released into the atmosphere.

History of the Rainier Shot

Many persons had considered the idea of containing a nuclear detonation deep underground following early test firings of nuclear devices. The specific test method employed last September grew out of suggestions by Dr. Edward Teller, of the University of California Radiation Laboratory, and of David Griggs, of the University of California at Los Angeles. The project was planned and conducted by the Livermore Branch of the Radiation Laboratory. The preliminary calculation and design of the experiment were carried out at Livermore, resulting in a self-sealing tunnel in which the shock from the explosion would close with rock a portion of the tunnel before the air shock wave, travelling through the tunnel, reached the sealed-off portion. A number of operation benefits was expected to be derived from deep underground detonations of nuclear devices. Among these were : (*a*) the total absence of fall-out ; (*b*) the absence of blast and flash effects on off-site residents and travellers ; (*c*) the elimination of radioactive clouds which interrupt and interfere with air traffic.

Both technical and environmental problems had to be answered before a deep underground shot could be firmly scheduled and fired. When a nuclear device is detonated atop a tower, suspended from a balloon, or dropped from an aircraft, photographic and other measurements can be made of the growth of the fireball, and samples of the fission products can be readily captured for radiochemical analysis. Obtaining measurements of a like nature when the burst was deep underground required the development of new techniques. The environmental problems included determining the proper depth of placement to avoid breaking the earth's surface, possible contamination of ground water, and seismic or earth shock effects both on and off the test site.

Preliminary Studies

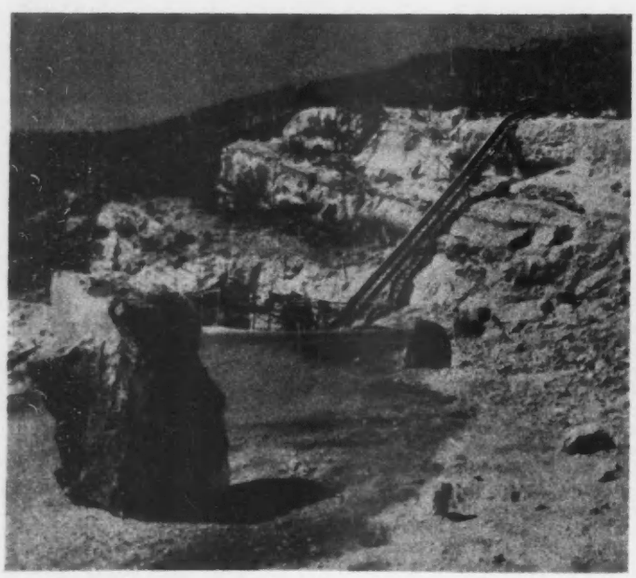
Several methods of underground placement were investigated by the test division of the Radiation Laboratory at Livermore in 1956. Of the two methods considered most feasible it was determined that a horizontal tunnel would be superior, from the standpoint of both cost and accessibility, to a vertical shaft or drill hole. The U.S. Geological Survey was asked to analyse the geological structures in and surrounding the mesa that had been selected as the most favourable site for the Rainier detonation, and to determine, to the extent possible through high explosive detonations, the containment and seismic aspects of a nuclear detonation inside the mesa. As part of these studies, two high explosive charges were fired in a tunnel bored into the mesa face. A 10-ton charge was fired at a depth of 92ft and a 50-ton charge at a depth of 165ft below the surface. Results obtained from these detonations were scaled up to the approximate 2-kiloton yield of the selected nuclear device.

The conclusions drawn from the U.S. Geological Survey studies were that no crater was expected from the Rainier detonation, but that probably the rock would be fractured to the surface ; that the shot tunnel would be considerably damaged by spalling, or caving in of the ceiling and walls ; and that large blocks of rock would be dislodged from the top of the mesa. Small quantities of radioactive gases, fission products, and possibly steam or water, might be vented through cracks in the rocks and "earth shock" seismic waves generated by the Rainier explosion would be below damage levels at a distance of about 10 miles, well within the test site and the adjacent Las Vegas bombing and gunnery range.

An advisory panel was established several months before the scheduled date of the Rainier detonation to examine the question of whether a deep underground nuclear explosion might trigger an earthquake. Among the topics suggested for panel study were : (*a*) the frequency of natural earthquakes in the area so as to provide an estimate of the probability of a coincidental earthquake, and (*b*) the consideration of the possibility of ground water contamination. After completing its study, the panel reported in April, 1957, that the proposed shot would not generate seismic signals any larger than those produced by the largest air bursts previously fired at the test site ; that no earth shock would be felt in Las Vegas ; and that the detonation would not trigger a natural earthquake. Seismological experts on the panel pointed out that earthquakes themselves do not trigger other earthquakes. They felt, further, that if there had been a geological situation in the test site region favourable for the triggering of an earthquake, earlier detonations at the site or the great Nevada earthquake of December 16, 1954, would have triggered it. The panel reported also that the possibility of ground water contamination was very remote. On the basis of the panel's report, a decision was made to continue with the preparations for firing the deep underground shot.

Rainier Shot Tunnel

A contract for drilling the Rainier shot tunnel was let to E.C. Nickel and Co., of Arcadia, California, in April, 1957, on a low bid of 314,210 dollars. The tunnel design that had been finally adopted called for boring through the rock for a total distance of 1900ft. The tunnel design called for a horizontal shaft 6ft wide by 8ft high. Toward the end of the tunnel, the shaft made a right-angle turn to the right and then made another right-angle turn to the right, after which it looped back upon itself until the shot chamber was reached in the middle of the "hook" thus formed. The purpose of the tunnel shape was to



Figs. 1 and 2—(Left) General view of terrain at Nevada test site, with pieces of weathered rock dislodged from the rim of the mesa which contained the underground nuclear shot. (Right) Radiation monitors checking the atmosphere at the mouth of the tunnel a few minutes after the Rainier detonation

locate the detonation chamber so that the nearby tunnel shaft would be closed by blast effects before any energy manifestations could travel around the "hook" and escape through the tunnel.

The geological name of the rock formation in which the tunnel was drilled is "Oak Springs Tuff." The rock formation is quite similar to those found in many places throughout the Nevada Test Site. It was deposited originally through volcanic activity. The tufa or tuff is a rather porous rock and it is felt that this feature, which permitted the rock to serve as an absorber for the nuclear detonation, prevented the ground shock waves from being felt more strongly at a distance from the shot.

Test Results

Early exploration of the shot tunnel to within 200ft of the centre of detonation resulted in finding no radiation above background. Considerable damage to the tunnel was found in the last 300ft that was still open. At approximately 200ft from ground zero the tunnel was sealed by rock. A drilling contractor had been employed to perform core drilling operations and it was decided to begin drilling from the top of the mesa. The drilling system contained built-in safety features and was designed for remote operation in the event that the drill penetrated a high-pressure region. The drilling was continued to a point at the same elevation as ground zero, at which point the drill had been displaced about 17ft off centre. During the drilling operation a cavity about 25ft in depth was encountered at a point about 385ft above ground zero and below the cavity the drill passed through broken rock until drilling was discontinued. At no point in this drilling operation were any high-pressure regions or pockets encountered. After the vertical drilling had reached the level of ground zero, the operation was suspended and horizontal drilling was begun from within the tunnel at a position 211ft from ground zero. The first hole drilled from within the tunnel was aimed directly at the point of detonation and, about three and a half months after the detonation, encountered zones of relatively high radiation and thermal temperature within 100ft of ground zero. The normal rock temperature was about 63 deg. Fah. At a distance of 60ft from ground zero a rock temperature of 113 deg. Fah. was encountered and this decreased to a fairly constant reading of 90 deg. Fah. from a distance of 35ft to ground zero. Subsequent drilling to volumes below the point of detonation revealed temperatures as high as 190 deg. Fah. A maximum radiation reading of about 45 röntgens per hour was recorded at about 50ft below ground zero.

Because of the unique deep underground placement of the Rainier device, seismologists and geophysicists were interested in earth measurements that might be obtained from registering shock waves created by the detonation. Even though a panel of experts had concluded that earth waves would be no greater than those caused by some previous air detonations at the site, particular efforts were made by many seismologists to record the effects of the shock waves generated by the Rainier detonation. When the device was detonated, only a few persons of many who witnessed the event from the forward control area, 2½ miles from ground zero, felt any earth shock, and off-site the earth movement was so slight that it could be recorded only on extremely sensitive seismological instruments. The earth waves were recorded at seismological stations at Los Angeles, about 250 miles away from the shot mesa. This was the maximum distance at which the shock was recorded.

The instruments used for measurements of the Rainier detonation, located in and around the shot chamber, operated successfully. The Livermore scientists feel that the results obtained by instrumentation verify their calculations that a nuclear detonation not only can be contained in a deep underground location, but that diagnostic and other necessary measurements can be obtained successfully. They conclude that certain experiments which require good collimation and massive shielding can best be accomplished underground. Another conclusion, after studies of the mesa through observation of the exterior and through drilling, is that shots with much larger yield can be fired in a deep underground chamber with little or no resulting air contamination and with no seismic hazard. It is concluded also that practically all of the fission products in the Rainier test were trapped in highly insoluble fused rock so that no ground water contamination problem resulted.

From the heat and radiation levels recorded and from the condition of the shattered and crushed rock around the shot zone, it was concluded that the detonation had created a spherical cavity around ground zero, and that for a very brief time the rock around the circumference of the cavity had been formed into a glass-like substance so that in effect a "glass ball" about 110ft in diameter existed. Quite soon, it is believed, the weight of the shattered rock above the glass ball crushed the sphere and rock fragments fell into the cavity and filled it. The falling rock resulted in a cavity at the top of the crushed rock zone, and it was this cavity that had been encountered in vertical drilling operation 385ft above ground zero. There had been speculation before the Rainier device was detonated that the intense heat and pressures generated might result in the formation of precious gems of some kind. Drilling operations have uncovered no evidence that such gems were created, and it is believed unlikely that they exist in or around the shot area. In an effort to obtain more detailed knowledge of the effects of the Rainier detonation within the burst area, a tunnel shaft now is being dug toward ground zero from the original shot tunnel. The new shaft originates near the point from which the horizontal core drilling was conducted.

The Livermore Branch of the University of California Radiation Laboratory now is engaged in "Project Plowshare," an investigation into the possible application of nuclear detonations for peacetime purposes. Considerable information that will be of interest in "Project Plowshare" was obtained from the Rainier detonation and the studies that have followed it. For example, it has been calculated that the underground shot produced at least 50,000 tons of permeable broken rock and an additional 400,000 tons of crushed, but relatively impermeable rock. The large masses of broken rock suggest such applications as use in mining to break up ore bodies for removal or leaching, and in oil strata to free crude oil trapped in relatively non-porous rock formations. It also is considered possible that heat resulting from an underground detonation in oil strata might increase the production of oil in certain situations by making it flow more freely through the rock formation.

Other possible peacetime applications include: (1) piping water into a rock formation heated by a contained nuclear detonation to form steam for producing power or for other uses; (2) placing various materials around a device to be detonated deep underground so as to effect changes in the materials through nuclear reaction; (3) further investigations of the make up of the earth's crust through seismic studies of earth waves resulting from deep underground detonations; (4) moving earth in quantity, such as in digging a large canal.

Refinery Process Pilot Plant

A computer controlled pilot plant for saving scientific manpower and reducing the time required to develop new catalytic refining processes is under construction at the Consolidated Electro-dynamics Corporation of Passadena, California, for the Esso Research and Engineering Company at Linden, U.S.A. The plant, compact enough to fit into an office, will be used to evaluate small-scale processes and will automatically provide a complete chemical analysis of samples of one drop of liquid in a fraction of the time now needed. After initial instructions are fed in, the desk-size computer takes over and automatically conducts tests and constantly analyses raw materials and products. Temperatures, pressures, flow rates and chemical compositions and other variables are fed several times per second into the computer, which digests the data and prints a complete record as the tests progress. Thus, it is possible to explore a new process within weeks rather than months.

As designed, the plant will serve a variety of purposes and will consist of three main systems, namely, services, reactor and product recovery. The controls will enable the catalyst evaluation programme to proceed automatically after the introduction of the catalyst cartridge into the reactor section. The programme will include automatic pressure test for leaks, oil circulation, catalyst treating cycle, regeneration cycle and a shut down after a predetermined number of cycles. Temperatures, pressures and compositions of gas and liquid streams will be monitored, controlled and recorded and the unit will close down if an uncontrolled condition outside preset limits is detected. Ability to follow quickly changes in chemical compositions should reduce the length of run, and since only a fraction of a millilitre will be required, instead of 800 to 1000 millilitres needed for empirical tests, the unit will be operated only long enough to achieve equilibrium. This reduction in test programme time will permit of an economical look at a wider range of variables, and also provide more accurate data, since large corrections for changes in catalyst activity will not be necessary. Furthermore, in a given period, the number of determinations of yields can be increased and thus trends such as deactivation rate can be determined at shorter intervals and with greater precision.

Seven analysers will be incorporated, including two consolidated vapour-liquid partition chromatographs, for the analysis of liquid hydrocarbons boiling up to 165 deg. Cent., while the product gas stream will be analysed for hydrogen and C_1-C_6 hydrocarbons by a third chromatograph. During the regenerations, oxygen, hydrogen, carbon dioxide and water will be determined, respectively, on a continuous basis, by the following instruments: Hayes para-magnetic analyser; Consolidated thermal conductivity analyser; Mines Safety Appliances infra-red analyser and Consolidated moisture analyser.

American-Built Greek Research Reactor

The U.S. Government will contribute 350,000 dollars toward the cost of a nuclear research reactor project being undertaken by the Greek Atomic Energy Commission near Athens. Greece is the ninth nation to receive financial assistance from the United States under President Eisenhower's Atoms-For-Peace proposal of June, 1955. The funds have been made available to the Commission by the U.S. International Co-operation Administration from Mutual Security funds and will be transferred to the Government of Greece upon completion of the project which is expected within the current year.

The reactor project has been planned to incorporate a broad programme of training and research and will be available to all Greek scientists and engineers through universities, hospitals, industrial laboratories, or by direct arrangement with the Greek Atomic Energy Commission. Practical experiments will be pursued in radioactivity measurements on soils, minerals and waters, and surveys of uranium and thorium ores. The reactor is a 1MW heterogeneous, pool type unit being manufactured and assembled by AMF Atomics of New York. The fuel element is being fabricated by Babcock and Wilcox. The Greek Atomic Energy Commission will construct and operate the facility. The Greek A.E.C. also will build a "hot laboratory," several laboratories for the physical sciences, a machine shop, offices and a library as supporting facilities. American personnel will assist the Greek staff during the start-up of the reactor and for approximately two months thereafter. The operating staff will consist of university scientists and other Greek employees including a number of persons who have been trained at the International School of Nuclear Science and Engineering at the Argonne National Laboratory. The Greek A.E.C. has established a programme which includes training sixteen men per year in the United States in various nuclear science and research disciplines.

Personal and Business

Appointments

CAUSEWAY REINFORCEMENT, Ltd., announces that Mr. Desmond Bowditch has been appointed a director.

MR. L. STUBBS, A.M.I.Mech.E., A.M.I.Loco.E., has been appointed engineer-in-charge (locomotives) of Ruston and Hornsby, Ltd.

MR. C. H. FLURSCHEIM, M.I.E.E., chief electrical engineer of Metropolitan-Vickers Electrical Company, Ltd., has been appointed a director.

RANSOMES, SIMS AND JEFFERIES, Ltd., has announced that Mr. Peter Dorling has been appointed chief buyer in succession to Mr. G. S. Andrews, who has retired after fifty-five years' service with the company.

MR. FRANK FAUX, A.M.I.E.E., chief assistant engineer to the system planning engineer of the Central Electricity Generating Board, has been appointed station planning and development engineer to the Board.

Business Announcements

WILLIAM TOWNSON AND SONS, Ltd., Bolton, has become a member of the Natural Asphalte Mine-owners and Manufacturers Council.

BARLOW-WHITNEY, Ltd., states that its Midlands office has been removed to 44, Queen's College Chambers, Paradise Street, Birmingham, 1 (telephone, Midland 6897).

MR. GEORGE BOEX, a former managing director of the British Aluminium and Associated Companies, is to retire from the board by rotation on May 6. He is to continue in a consultative capacity.

SHORT AND MASON, Ltd., states that it has signed an agreement with Aktiengesellschaft Chemisches Institut Dr. A. G. Epprecht, Zurich, whereby it will act as sole agent in Great Britain for Drage instruments.

MASSEY-FERGUSON announces that the United Kingdom companies of the agricultural machinery organisation previously known as Massey-Harris-Ferguson, will in future be known as Massey-Ferguson.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY, Ltd., and TUBE INVESTMENTS, Ltd., announce that an agreement has been reached for the merging under the name of Henley-Simplex Africa (Pty.), Ltd., of their businesses in South Africa previously carried on by Henley's (South Africa) Telegraph Works Company, Ltd., and Simplex Electric Company (South Africa) (Pty.), Ltd.

Contracts

THE WESTPORT SHIPPING COMPANY, Ltd., has placed an order with Mirrlees, Bickerton and Day, Ltd., for two KVSSDM vee twelve-cylinder, turbo-charged diesel engines of 2100 s.h.p. at 310 r.p.m., for installation in the cargo ship M.V. "Mano."

D. NAPIER AND SON, Ltd., has received an order for twenty-four Napier "Deltic 18" diesel engines, each of 3100 s.h.p. The engines are to power twelve fast patrol boats, each of 68 tons displacement, which are being built by Boatservices, Ltd., of Oslo, for the Norwegian Government.

Miscellanea

IMPROVED TRANSMISSION.—A five-speed gearbox is now optional on most forward-control Bedford commercial vehicles. The changes are, downward from direct drive, 1·47, 1·52, 1·69, and 1·87; the closer ratios have allowed synchromesh to be abandoned. Helical gears are used for the two highest indirect ratios, sliding gear engagement for the remainder. Provision is made for power take-off on either side of the box.

ALUMINIUM IN PACKAGING.—The Aluminium Development Association, 33, Grosvenor Street, London, W.1, announces that a symposium on "Aluminium in Packaging" will be held at the Savoy Hotel on Thursday, June 12. Eight papers will be presented: those in the morning will deal with aluminium as a packaging material and those in the afternoon will discuss the uses of aluminium in particular aspects of packaging.

NEW DOUBLE REDUCTION UNIT.—A new "2¼" "Radicon" double reduction worm reducer introduced by David Brown Industries, Ltd., Stonebridge Park Works, London, N.W.10, is designed for low-powered, slow-moving drives. It provides a choice of fifty-three ratios between 65 : 1 and 3600 : 1, with a corresponding range of output torques between 1270 lb and 3300 lb per inch at input speeds from 500 to 3000 r.p.m. The standard ratios of the "1⅝" and "2¼" "Radicon" single reduction units are combined to give this range of ratios, allowing the use of the single reduction unit gears with the exception of the second reduction worm shaft. Detachable feet are fitted and alternative facings provided, so that the unit can be mounted in a number of different operating positions.

DOCK LEVELLING RAMP.—Dock levellers such as those in the Ford Parts Division at Aveley, Essex, described and illustrated on April 20, 1957 (page 653), are now available from The Wayne Tank and Pump Company, Ltd., Western Road, Bracknell, Berks, under the name "Dock-o-matic." The ram hydraulic system is energised and controlled electrically; single or three-phase equipment can be supplied. The ramp will remain in place under a load of up to 20,000 lb, but the hydraulic system is not protected against overloading of the ramp.

AIR-OPERATED STIRRER.—A portable air-operated stirrer made by the Kestner Evaporator and Engineering Company, Ltd., is driven by a rotary vane air motor suitable for working pressures of up to 90 lb per square inch, with integral sun and planet reduction gear driving a stainless steel, or plastic coated, shaft which is fitted with two opposed propellers. It is small and light in weight and completely flameproof. An air control provides variable speed operation, and the stirrer is provided with an adjustable bracket and mounting clamp for direct attachment to the rim of the mixing vessel.

DRILLING MACHINE.—A 1¼in capacity drilling machine now being made by Grimstone Electric Tools, Ltd., Progress Way, Croydon, Surrey, has a motor-driven geared head giving eight spindle speeds from 51 to 1300 r.p.m., and four feeds from 0·0055in to 0·0105in per revolution. Its head has means of rack and pinion adjustment on the column and the spindle feed length is 6in. An 18in square work table can be raised, lowered and swung on the column and has a maximum setting of 28in below the spindle nose. The table can be swung clear to allow work to be mounted on the table base, which is 48in below the spindle nose.

PROTECTIVE COATING.—A protective coating for metal and concrete surfaces developed by Wailes Dove Bitumastic, Ltd., Hebburn, Co. Durham, and called "Epimastic," is said to combine the waterproofing properties of coal-tar-pitch with the resistance to chemical attack and corrosion of epoxy resins. The material is claimed to adhere well to both metal and concrete surfaces and to be able to withstand exposure to acids, alkalis, oils, fats and many other corrosive chemicals. The material is supplied in two component packs consisting of a base and a catalyst which are mixed in correct proportions before application.

LARGE PIPELINE VALVES.—Oil pipeline valves of a size previously manufactured only in the U.S.A. are now being made by the David Brown Foundries Division, Penistone, to the order of the W.K.M. Valve Company (Britain), Ltd., for use by the Shell Petroleum Company in Venezuela. The three sizes of valve so far produced have bore diameters of 16in, 24in and 30in, respectively. They have cast carbon steel bodies moulded in three sections, the largest of the valve assemblies being approximately 10ft high and weighing more than 8 tons. Submerged arc welding is used in assembling the main body castings, which are required to withstand pressures up to 2400 lb per square inch.

INFORMATION ON CAST CONCRETE PRODUCTS.—A series of data sheets has been published by the British Cast Concrete Federation, 105, Uxbridge Road, Ealing, W.5. Technical information on the various products—described either as cast stone or cast concrete—manufactured by members of the Federation, is given in these sheets. There are over a hundred such products, excluding individually designed ones, many of which are illustrated. The sheets include information on relevant British Standards, surface treatments, and such like matters, but are arranged according to the type of product; there are, for instance, sheets on pipes, agricultural buildings, pavement lights, and lintels, to quote examples.

RAISING THE STEENBRAS DAM.—Some years ago the Steenbras dam, which is a key structure in the water supply of Capetown, was raised in height by 6½ft, using the method of M. Coyne to preserve stability. This method involves drilling holes vertically close to the face of the dam, inserting vertical cables, and tensioning them, between anchorages in the bedrock and at the crest of the dam. A film of this work has been made by the contractor—the Cementation Company, Ltd. The various stages in the work are explained in the film. It is stressed that operational water levels were maintained in the reservoir throughout the work, and, in fact, special haste was made to complete the heightening of the spillway in time to impound the wet season's flow to the new level.

PUBLIC SERVICE VEHICLES.—The regulations governing public service vehicles have been revised in a manner that will facilitate the use of small vehicles to carry not more than twelve passengers. The amendments relate to such matters as the width and height of entrances and internal gangways, the use of rear entrances, minimum road clearance and the positioning of fuel filling points on vehicles. They should enable many existing vehicles to be adapted at reasonable expense. Since these vehicles will be rather cramped in comparison with normal buses, standing passengers will not be allowed in them and the concession allowing three children to be carried in certain circumstances in the place of two adults will be restricted so that the total number of passengers, including children, may not on any occasion exceed fifteen. The regulations involved are the Public Service Vehicles (Conditions of Fitness) Regulations, 1958, and The Public Service Vehicles and Trolley Vehicles (Carrying Capacity) (Amendment) Regulations, 1958.

PORCELAIN INSULATORS.—A new film entitled "Porcelain Insulators in the Making," produced by Doulton Industrial Porcelains, Ltd., was shown for the first time in London recently. The company manufactures porcelain insulators to as many as 1200 different patterns, and some of the many uses of these insulators are illustrated in the film. The manufacturing processes in the company's factory at Tamworth are described in great detail, and stress is laid on the need for careful selection of materials used in the preparation of heavy-duty ceramic products. All insulators are carefully tested before despatch, including routine and sample tests to British standards and specifications and to American N.E.M.A. standards; one entire unit from every batch completed is broken up and tested for porosity, and final scenes show some of the tests carried out in the special high voltage laboratories where available plant includes equipment for power frequency tests up to 500kV and impulse testing to 1000kV. The film is available in 16mm size and runs for twenty-eight minutes.

FIRE RESISTANT ROOF CONSTRUCTION.—Reconstruction of Maville Works, Nottingham, which was gutted by fire on January 3, has been undertaken by the Sherwood Construction Company, Ltd. Only the walls and one floor of the building were left intact, the roof and second floor being almost completely burnt away. A new roof was planned and installed in less than nine weeks from the date of the fire, the actual construction including three layers of felt taking ten men only twelve working days to complete. The roof, which is the first of its kind in the Midlands, is "Pyrodek" gypsum concrete, recently introduced in this country by D. Anderson and Son, Ltd., Stretford, Manchester. The actual pouring of the gypsum deck (1000 square yards) was completed in twelve hours and whilst the clearing of the fire debris proceeded, so allowing the work to progress with full protection for the workmen. The "Pyrodek" roof construction, which has a two-hour fire rating, comprises gypsum formboard laid on to the flanges of bulb tee sections; this construction is then reinforced with galvanised reinforcing fabric. Gypsum concrete is mixed at ground level in an automatic mixing and gauging unit and pumped into place on the formboard to a minimum depth of 2in, giving an overall minimum depth of 3in.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—At a meeting of the North-East Coast Institution of Engineers and Shipbuilders held on February 7, a paper entitled "Some Shrouding and Tip Clearance Effects in Axial Flow Compressors" was read by J. L. Jefferson, B.A., and R. C. Turner, B.Sc. (Eng.). The paper, with a reference to the economics of blade manufacture, explains the reasons for the main series of tests, which were carried out at the National Gas Turbine Establishment, the material being supplied by C. A. Parsons and Co., Ltd. Four series of tests are described in detail. Various combinations of shrouding and tip clearance were investigated, untwisted constant-section blading being used in the first three series. The experiments were carried out over a range of shrouding leakage clearances, and also included an investigation of the boundary layer flow on the convex surface of a stator blade in the compressor. A brief review of published work on the effects of normal radial tip clearance is followed by a description of some early results obtained on a multi-stage compressor. It is concluded that shrouding of the type investigated should, if possible, be avoided, especially under certain aerodynamic conditions. If it is necessary that it be used, the clearance should be maintained at the smallest practicable value. The use of very fine radial tip clearances may also result in a loss of performance, although values in excess of 1 per cent of the blade height are also shown to be undesirable in the particular case investigated.

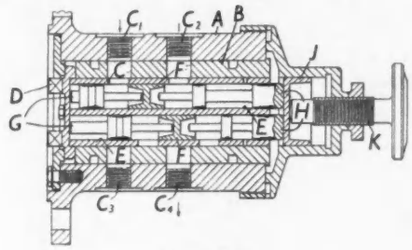
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

INTERNAL COMBUSTION ENGINES

791,254. October 4, 1955.—LIQUID FUEL METERING DEVICES, Joseph Lucas (Industries), Ltd., Great King Street, Birmingham, 19. (*Inventor: Eric William Downing.*)

The invention relates to liquid fuel metering devices for use on internal combustion engines, and of the kind comprising a reciprocatory shuttle contained in a longitudinal bore in a cylindrical rotary valve, the fuel being discharged alternately from either side of the shuttle by pressure of the fuel acting on the other side. The object of the invention is to provide an improved form of device for use particularly on an engine having a large number of cylinders. Referring to the drawing, the body part *A* has formed in it a cylindrical bore into which is inserted a liner *B*, the body and liner being provided with appropriately arranged inlet and outlet ports. In the liner is contained a cylindrical rotary valve *C* adapted at one end for connection by a coupling *D*



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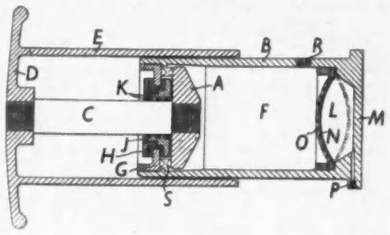
to the engine. The valve has formed in it two longitudinal bores *E* of similar size parallel with each other at opposite sides of the axis of the valve. Each bore contains a reciprocatory shuttle *F* and also a pair of end stops *G* and *H*. The stop *G* occupies a fixed position and the stop *H* is free, so that its position can be varied for varying the range of movement of the shuttle. In the end of the body adjacent to the adjustable stops *H* is a cylindrical and axially adjustable abutment *J* which supports each of the adjustable stops so that the stops can be adjusted equally. Adjustment of the abutment *J* may be effected by a screw *K* or by any convenient mechanism which is automatically movable in response to, for example, the air pressure in the air induction pipe of the engine. Ports are provided in the valve at positions adjacent to the ends of the shuttles, as shown in the drawing, and inlet and outlet ports are arranged in the body part to coincide with the valve ports at successive intervals during the rotation of the valve. In the example illustrated by the drawing there are shown a pair of inlet and outlet ports C_1 and C_2 associated with the shuttle in the upper bore. A second pair of such ports are situated at 90 deg. from the ports C_1 and C_2, and a third pair, indicated by C_3 and C_4, are provided at 180 deg. from the ports C_1 and C_2. Similar inlet and outlet ports are also provided in the body part to coincide with the ports in the valve associated with the other shuttle. The number and arrangement of inlet and outlet ports provided in and at equiangular positions around the body part depends on the number of cylinders in the engine. For an eight-cylinder engine each shuttle supplies four cylinders, and the arrangement of the ports is made such that the cylinders are supplied in the desired sequence. The action of the metering device is similar to that of other devices of the same type, but the construction differs in that at least two shuttles are provided in separate bores in the rotary valve.—*February* 26, 1958.

RAILWAY ENGINEERING

791,869. February 6, 1956.—BUFFERS FOR RAILWAY ROLLING STOCK, Les Ateliers De Construction Du Nord De La France, Crespin-Blanc-Misseron (Nord), France.

As will be seen from the drawing, the buffer comprises a piston *A* slidably mounted in a piston cylinder *B*. The piston is rigidly connected, by a piston rod *C*, to a buffer plate *D*. A cylindrical skirt portion *E* forms a guide for the sliding of the piston rod and piston. The cylinder space *F* is filled with a damping fluid such as oil. This space is closed in front by a cover *G* through which the piston rod passes. The cover is provided, through a part resilient mounting *H*, with a hub *J* which allows slight lateral displacements of the rod without risk of impairment of the fluid-tight sealing provided by rings *K* between the rod *C* and the hub *J*. The compensator-recuperator device comprises a body of a suitable gas, such as nitrogen, enclosed in a chamber *L* which is bounded by the end plate *M* of the cylinder and a resilient membrane *N* of reinforced synthetic rubber, supported against a perforated partition *O*. A supply conduit *P*, closed by a plug, is formed in the plate *M* for filling the chamber *L*. A supply aperture *R*, also closable by a plug, is provided in the wall of the cylinder for filling the space *F* with oil, and abutments *S* of resilient material, mounted on the cover *G*, limit the return



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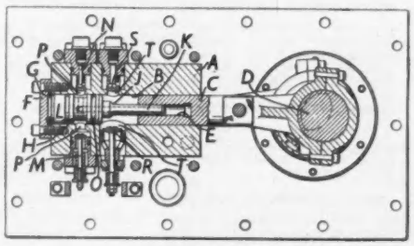
stroke of the piston. When the plate *D* of the buffer receives a concussion the piston rod moves and the piston *A* driven by the rod, exerts a compression force on the oil contained in the space *F*. As the pressure on the oil increases, the resilient membrane *N* of the compensator-recuperator system is deformed and in turn compresses the body of gas confined in the chamber *L*. The effect of this deformation of the membrane as the piston moves inwardly is to increase the volume of the space *F* by a volume equal to that which the piston rod *C* occupies in this space. Simultaneously, a part of the oil passes from the front to the back of the piston *A* through grooves formed in the cylinder or through an annular space provided by a conical boring of the cylinder; progressive dimensioning of the bleeding passages allows the pressure to rise slowly at the beginning of the piston stroke and then more rapidly, so that the force exerted in resistance to the piston absorbs the energy of the concussion. There is obtained, for a buffer stroke of 200mm, for example, an absorption of energy which is a function of the oil in the cylinder. For a final pressure of the order of 200 kg per square centimetre, there may be absorbed 8500 kg.m, that is to say, an energy substantially equivalent to the concussion of two wagons striking each other with a relative speed of 15km per hour.—*March* 12, 1958.

PUMPS

791,865. December 17, 1954.—RECIPROCATING PUMP, W. and T. Avery, Ltd., Soho Foundry, Birmingham, 40. (*Inventor: Philip Benjamin Hinde.*)

The invention relates to an improved reciprocating pump designed to deliver hydraulic fluids simultaneously at two different pressures. As the drawing clearly shows, the pump *A* incorporates a cylindrical bore *B* within the one end of which is a sliding plunger *C* reciprocated by a crankshaft *D*. This plunger has a bore *E* which is open at the inner end. The opposite end of the bore *B* in the pump body is closed by a plate *F* which serves to locate a flange *G* at one end of a fixed closure plug *H*. This fixed plug at the end remote from the flange is formed with a stem *J* which fits within the bore *E* in the plunger *C*



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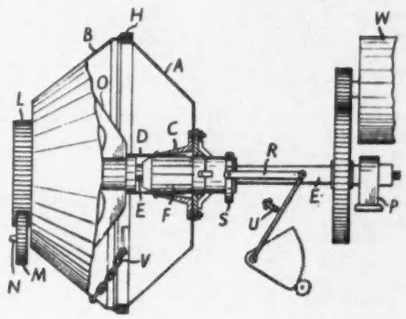
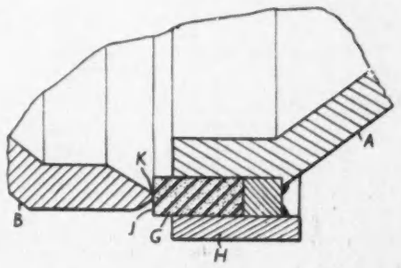
and has a longitudinally extending passageway *K* therein which is in communication through laterally extending passageways *L* with a non-return spring-loaded inlet valve *M* and a non-return spring-loaded delivery valve *N*. The major diameter of the plug *H* fits in the bore *B* in the pump body and has on each side of the lateral passageways a peripheral groove in which is accommodated a sealing ring *O* which permits a limited lateral movement of the plug *H* so that the stem *J* of this plug can align itself with the bore *E* in the plunger. It will be understood that the lateral passageways *L* in the fixed plug are in communication with ports *P* in the pump body in which the non-return inlet and delivery valves are accommodated. A second pair of non-return spring-loaded inlet and delivery valves *R* and *S* are provided in ports *T*, extending from the bore *B* in the body surrounding the stem *J* of the fixed plug. When the plunger *C* is reciprocated, the bore *E* of this plunger will become the pumping chamber of one pumping system, a hydraulic fluid being drawn through the associated inlet valve *M* by way of the passageway *K* in the fixed plug *H* and delivered by way of this passageway through the associated delivery valve *N*. Simultaneously the annular space surrounding the stem *J* of the plug will constitute the pumping chamber of a second independent system incorporating the inlet and delivery valves *R* and *S*. In practice, the dimensions of the bores are arranged so that the bore *K* in the reciprocatory plunger constitutes the pumping chamber of a relatively high pressure system, whilst the annular space surrounding the stem *J* of the fixed plug constitutes the pumping chamber of a relatively low pressure system. Thus, from a pump having a single plunger a simultaneous delivery at two different pressures is provided.—*March* 12, 1958.

CONTRACTORS PLANT

792,240. July 3, 1956.—CONCRETE MIXERS, Fritz Moser, 32, Dufourstrasse, Zollikon, Switzerland.

In the drawing is shown a concrete mixer comprising a drum formed by two truncated tubs *A* and *B*. The tub *A* is axially movable and is integral with a conical sleeve *C*. During the axial displacement of the tub the sleeve slides over a protective tube *D* fitted on a rotary shaft *E*. The tub *A* is secured to bearing *F* which enables the tub to slide on the shaft. This tub can be displaced to separate it from the tub *B*





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to allow the emptying of the concrete. The tub *A* carries, according to the invention, and shown in the lower view, a deformable strip *G* lodged in a groove provided by a hoop *H* on the tub. When tubs *A* and *B* are closed together, the element presents a flat edge *J* coming into contact with an edge *K*, preferably chamfered, of the tub *B* so that the edges of the tubs themselves are not in contact with each other. The tub *B* has a bearing band *L* supported by rollers *M* rotating on fixed pivots *N*. It is fixed to the rotary shaft *E* by the arms *O* keyed to this shaft, the remote end of which is mounted in a bearing *P*. The tub *B* has an axial opening into which a hopper, not shown, can be introduced, for introducing the ingredients of the concrete. The axial displacement of the tub *A* with respect to the tub *B* is effected by means of a connecting-rod *R*. One end of this rod is linked to a stirrup *S*, mounted in a collar fixed to the movable bearing *F*. The other end of the rod *R* is linked to a lever integral with a toothed segment which engages with a pinion as shown. The latter can be set into rotation, for example, by a hand-operated control wheel. The segment is provided with locking means, allowing it to be locked in a selected position, whereas an adjustable stop *U* restricts the extent of the approach of the movable tub in order to limit the degree of compression of the deformable strip. The tub *A* is rotated by an articulated chain *V* fixed to tub *B*. The shaft *E* is rotated by a gear wheel which engages a pinion fitted to shaft of a motor *W*.—*March* 19, 1958.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, April 11.—STOKE AND CREWE BRANCH: Grand Hotel, Hanley, Stoke, "Electrical Safety," J. Jones, 7.30 p.m. ★ LIVERPOOL BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, "General Factory Requirements for Electrical Installations," D. A. Picken, 7.30 p.m.

Sat., April 12.—OXFORD, READING AND DISTRICTS BRANCH: Hampden Buildings, Temple Square, Aylesbury, "Lighting Installation Design," 7 p.m.

Mon., April 14.—CENTRAL LONDON BRANCH: White Hall Hotel, Bloomsbury Square, London, W.C.1, Three Short Papers, 6.30 p.m. ★ NORTH EAST LONDON BRANCH: Angel Hotel, Ilford, "Automation in the P.L.A.," F. W. Sheppard, 8 p.m. ★ NORTH WEST LONDON BRANCH: Century Hotel, Forty Avenue, Wembley Park, "Planned Maintenance," R. A. Hope, 8.15 p.m.

Tues., April 15.—OXFORD, READING AND DISTRICTS BRANCH: Agricultural Hall, 121, Oxford Road, Reading, "Electrical Ventilation," 7.15 p.m. ★ TYNESIDE BRANCH: Crown Hotel, Clayton Street West, Newcastle, "Railway Signalling," 7.30 p.m.

Thurs., April 17.—KENT BRANCH: County Hotel, Canterbury, "Transistors," F. Szekely, 7.30 p.m.

Sat., April 19.—OXFORD, READING AND DISTRICTS BRANCH: Collier Lecture Room, Regent's Park College, Pusey Street, Oxford, "The Building of the Berkeley Atomic Power Station," 7 p.m.

BRITISH COMPUTER SOCIETY

Mon., April 21.—York Hall, Caxton Hall, Westminster, London, S.W.1, "The Use of an Electronic Computer in Research Statistics: Four Years' Experience," F. Yates, 6.15 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., April 15.—LONDON SECTION: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Factors in the Design of Airborne Doppler Navigation Equipment," E. G. Walker, 6.30 p.m.

Thurs., April 17.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Annual General Meeting; Films, 7 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Thurs., April 17.—SCOTLAND REGION: Grand Hotel, Charing Cross, Glasgow, C.3, "Present Practice and the Future of Coal Burning Equipment," H. E. Pearsall, 10.30 a.m.; "Future Developments in Steam Generators," H. A. Cameron, 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, April 11.—LEEDS CENTRE: Mansion Hotel, Roundhay Park, Leeds, 8, Annual General Meeting, 7 p.m.

Mon., April 14.—SHEFFIELD CENTRE: Grand Hotel, Sheffield, Annual General Meeting; "The Contribution of Plastics to Lighting Practice," W. E. Harper, 6.30 p.m.

Tues., April 15.—LIVERPOOL CENTRE: Committee Rooms, Liverpool Passenger Transport Office, 24, Hatton Garden, Liverpool, 3, Annual General Meeting, 6 p.m.

Thurs., April 17.—MANCHESTER CENTRE: Demonstration Theatre, N.W. Electricity Board, Town Hall, Manchester, 2, Annual General Meeting; Members' Night, 5 p.m.

Mon., April 21.—BATH AND BRISTOL CENTRE: South Western Electricity Board, Bath, Annual General Meeting, 7 p.m. ★ LEICESTER CENTRE: Bell Hotel, Leicester, Annual General Meeting, 7 p.m.

INCORPORATED PLANT ENGINEERS

Wed., April 16.—KENT BRANCH: Railway Hotel, Dartford, "Jointings," W. E. Hoes, 7 p.m.

Thurs., April 17.—BLACKBURN BRANCH: Golden Lion Hotel, Blackburn, "Work Study in the Smaller Factory," P. A. Gibbs, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., April 15.—EAST ANGLIAN SECTION: Lecture Hall, Public Library, Ipswich, Annual General Meeting; Discussion on "Foundry Topics and Problems," 7.15 p.m.

INSTITUTE OF FUEL

To-day, April 11.—SOUTH WALES SECTION: South Wales Institute of Engineers, Park Place, Cardiff, "Planning and Maintenance of an Oil Refinery," W. G. Elgie, 6 p.m.

Mon., April 14.—NORTH EASTERN SECTION: Chemistry Lecture Theatre, King's College, Newcastle upon Tyne, Annual General Meeting, 6.30 p.m.

Thurs., April 17.—EAST MIDLAND SECTION: Gas Showrooms Lecture Theatre, Nottingham, Annual General Meeting, 6.15 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., April 15.—The Memorial Building, 76, Mark Lane, London, E.C.3, "Supercharged Boilers for Marine Application," E. L. Daman, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day, April 11.—SOUTH WALES CENTRE: South Wales Institute of Engineers, Park Place, Cardiff, Annual General Meeting, 7 p.m.

Mon., April 14.—EAST REGIONAL CENTRE: Council Chamber, Houldsworth Hall, 90, Deansgate, Manchester, Annual General Meeting, 7.30 p.m.

Tues., April 15.—EASTERN CENTRE: Golden Hind Hotel, Cambridge, Annual General Meeting, 7 p.m.

Wed., April 16.—NORTH REGIONAL CENTRE: Victoria and Station Hotel, Preston, Annual General Meeting, 7.30 p.m.

Thurs., April 17.—YORKSHIRE CENTRE: Great Northern Hotel, Wellington Street, Leeds, 1, Annual General Meeting, 7.30 p.m. ★ MET. AREA: Royal Society of Arts, John Adam Street, London, W.C.2, "The Adaption of Commercial Vehicles for Use in a Special-Purpose Mixed Fleet" R. H. R. Hacker, 6.30 p.m.

Mon., April 21.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, Annual General Meeting, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., April 16.—MIDLANDS BRANCH AND MIDLANDS GRADUATES' AND STUDENTS SECTION: Midland Institute, Paradise Street, Birmingham, "Synthetic Rubber Plants," A. E. W. Bailey, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., April 15.—Great George Street, Westminster, London, S.W.1, "Construction of Circulating Water Pump House at Cowes Generating Station, Isle of Wight," R. H. Coates and L. R. Slade, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, April 11.—LONDON GRADUATE AND STUDENT SECTION: Savoy Place, London, W.C.2, "Engineering Aspects of the British Controlled Thermonuclear Reactor Experiments," R. Carruthers, 6.30 p.m. ★ NORTH SCOTLAND SUB-CENTRE: Robert Gordon's Technical College, Aberdeen, "The Potentialities of Railway Electrification at the Standard Frequency," E. L. E. Wheatcroft and H. H. C. Barton, 7.30 p.m.

Mon., April 14.—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "The Future Trend of Installation Inspection," opened by Forbes Jackson, 5.30 p.m. ★ NORTH EASTERN CENTRE: Royal Station Hotel, Newcastle upon Tyne, Annual General Meeting and Conversazione, 6.15 p.m. ★ SOUTH MIDLAND CENTRE: Winter Gardens, Malvern, "Developments in Semi-Conductors," E. G. James, 7.30 p.m. ★ NORTH STAFFORDSHIRE SUB-CENTRE: Duncan Hall, Stone, "The Importance of Research in Hearing and Seeing to the Future of Telecommunication Engineering," E. C. Cherry, 7 p.m.

Tues., April 15.—MEASUREMENT AND UTILIZATION SECTIONS: Savoy Place, London, W.C.2, "A Train Performance Computer," E. Bradshaw, M. Wagstaff and F. Cooke; "The Simulation of Distributed-Parameter Systems," with Particular Reference to Process Control Problems," J. F. Meredith and E. A. Freeman; "A Magnetic-Drum Store for Analogue Computing," J. L. Douce and J. C. West, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION: Public Library, Chelmsford, "The Principles of Electronic Keyboard Instruments," B. Basham, 7 p.m. ★ EAST MIDLAND CENTRE: Loughborough College, Loughborough, Discussion on "The Application of Digital Techniques to Control," 6.30 p.m. ★ NORTHERN IRELAND CENTRE: Civil Engineering Department, David Keir Building, Queen's University, Belfast, "An Asymmetrical Induction-Motor Winding for 6 : 3 : 2 : 1 Speed Ratios," G. H. Rawcliffe and B. V. Jayawant, 6.30 p.m. ★ SOUTH-EAST SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "The Mechanical Strength of Power Transformers in Service," E. T. Norris, 7 p.m.

Wed., April 16.—SUPPLY SECTION: Savoy Place, London, W.C.2, in conjunction with the British Nuclear Energy Conference, "Operational Experience—Calder Hall," K. L. Stretch, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION: Visit to Post Office Cable Ship, H.M.T.S. 'Monarch,''' Erith, 2.30 p.m. ★ SHEFFIELD SUB-CENTRE: Grand Hotel, Sheffield, "The Use of Steel-Tank Mercury-Arc Inverters for Generating Medium Frequencies for Induction Heating," D. L. Smart and J. J. L. Weaver, 6.30 p.m.

Thurs., April 17.—UTILIZATION SECTION: Savoy Place, London, W.C.2, "2/1 Pole-Changing Motors," R. F. Burbidge; "Project Considerations for Diesel Electric Traction," R. S. Wignall; "Some Applications of Mercury-Arc Rectifiers," A. Wren, 5.30 p.m.

Fri., April 18.—SOUTH MIDLAND CENTRE: College of Technology, Gosta Green, Birmingham, "Training for the Electrical Trades," R. W. G. Ward, 6.15 p.m.

Mon., April 21.—WESTERN SUPPLY GROUP: South Wales Electricity Board, Demonstration Theatre, Electricity House, Colston Avenue, Bristol, "My Visit to the U.S.A.," J. S. Lombard, 6 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., April 14.—Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "Turbo-Car Progress," P. A. Phillips, 7.15 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, April 11.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, Symposium on "Trends in Road Foundations," 5.30 p.m.

Thurs., April 17.—YORKSHIRE AND LINCOLNSHIRE BRANCH: Wheatley Golf Club, Doncaster, Annual General Meeting; Presentation of Premium Award Prize-winning Paper, 7 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., April 16.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Steels for Railway Purposes," W. Barr and J. Dearden, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Tues., April 15.—AUTOMOBILE DIVISION: 1, Birdcage Walk, Westminster, London, S.W.1, Three Papers on "Petrol Injection," E. Gay, E. W. Downing and H. Heinrich, 4.30 p.m. ★ NORTH WESTERN A.D. CENTRE: Leyland Motors, Ltd., Leyland, Lancs, "The Motor Industry Research Association's Proving Ground," A. Fogg, 7.15 p.m.

Thurs., April 17.—APPLIED MECHANICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Training in Engineering Design," 6 p.m. ★ EAST MIDLANDS GRADUATES' SECTION: College of Further Education, Greenclose Lane, Loughborough, "A Short Review of the Radial Flow Steam Turbine in England," M. C. Lewis, 7.15 p.m. ★ YORKSHIRE GRADUATES' SECTION: Hotel Metropole, Leeds, Annual General Meeting; Films, 6.30 p.m.

Fri., April 18.—LONDON BRANCH: 1, Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting, 6 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., April 17.—Geological Society, Burlington House, Piccadilly, London, W.1, "Apparent Viscosities of Heavy Media and the Driessen Cone," E. O. Lilge, T. E. Fregren and G. R. Purdy; "Scientific Management Principles Applied to West African Mining," H. H. Fraser and O. E. A. Somerset, 5 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Wed., April 16.—Conference Room, 4th Floor, Waterloo Bridge House, London, S.E.1, "What's Abroad?" H. E. Francis and C. E. Clinch, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., April 14.—NORTHERN REGION: Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, Annual General Meeting; Tour of the Various Departments of Rutherford College, 7 p.m.

Tues., April 15.—PETERBOROUGH SECTION: Conference Room, Peterscourt, Peterborough, "Paints and Finishes," F. C. Faulkner, 7.30 p.m.

Wed., April 16.—WOLVERHAMPTON SECTION: Wolverhampton and Staffs College of Technology, Wulfruna Street, Wolverhampton, "Further Review of Electronic Control in Industry," E. Heys, 7.30 p.m. ★ SOUTH ESSEX SECTION: Ilford Club, 21a, Balfour Road, Ilford, "Recent Developments in Industrial Photography," P. H. Herbert, 7.30 p.m. ★ WESTERN GRADUATE SECTION: Royal Hotel, College Green, Bristol, 1, "The Production of Metal Components by the Sintering Process," B. H. Swan, 7.30 p.m.

Thurs., April 17.—LUTON GRADUATE SECTION: Assembly Room, Town Hall, Luton, Beds, "Work Study," C. J. Andrews, 7.30 p.m.; Annual General Meeting, 9.15 p.m.

Fri., April 18.—SWANSEA SECTION: Central Library, Alexandra Road, Swansea, Films, 7.30 p.m.

Sat., April 19.—WORCESTER SECTION: Visit to W. H. Allen and Co., Ltd., Atlas Works, Pershore, Worcs, 10.30 a.m.

Mon., April 21.—COVENTRY GRADUATE SECTION: Craven Arms Hotel, High Street, Coventry, Annual General Meeting; "Karakoram Himalayan Expedition, 1957," K. J. Miller, 7.15 p.m.

INSTITUTION OF PUBLIC HEALTH ENGINEERS

Mon., April 14.—Committee Room 15, Caxton Hall, London, S.W.1, Discussion on "Problems in the Pumping of Sewage and Water," opened by W. D. Haworth, 6 p.m.

Wed., April 16.—Caxton Hall, Westminster, London, S.W.1, "Pollution of Underground Water," G. Carter, 6 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., April 14.—BURTON-ON-TRENT SECTION: Midland Hotel, Station Street, Burton-on-Trent, Annual General Meeting, Films, 7.15 p.m. ★ MANCHESTER SECTION: Engineers' Club, Manchester, Annual General Meeting, 6.45 p.m. ★ MERSEYSIDE SECTION: Exchange Hotel, Liverpool, Annual General Meeting; Films, 7.15 p.m. ★ PRESTON SECTION: Bull and Royal Hotel, Church Street, Preston, Annual General Meeting; Films, "Rubber from Rocks" and "Point of New Departure," 7.15 p.m. ★ SOUTH WALES AND MONMOUTHSHIRE SECTION: Angel Hotel, Cardiff, Annual General Meeting, 7.30 p.m.

Wed., April 16.—SOUTHERN SECTION: Polygon Hotel, Southampton, Annual General Meeting; Films, 7.30 p.m.

Fri., April 18.—NORTH EASTERN SECTION: Eldon Grill, Grey Street, Newcastle, Annual General Meeting and Dinner, 7 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, April 11.—MIDLAND COUNTIES GRADUATES' AND STUDENTS' SECTION: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, Address by Branch Chairman, Annual General Meeting, 6.30 p.m. ★ SOUTH WESTERN COUNTIES BRANCH: Duke of Cornwall Hotel, Plymouth, "Some Constructional Projects in the Middle East," E. G. Cove, 5.30 p.m. ★ WESTERN COUNTIES BRANCH: Small Lecture Theatre, University Engineering Laboratories, The University, Bristol, Annual General Meeting; Talk by R. F. Maitland, 6 p.m.

Tues., April 15.—SCOTTISH BRANCH: Department of Civil Engineering, The University, Glasgow, "Continental Prestressed Reinforced Concrete Bridges," D. Vandepitte, 7 p.m.

Wed., April 16.—YORKSHIRE BRANCH: Central Electricity Authority Offices, Whitehall Road, Leeds, Annual General Meeting; "Some Structural Aspects of Nuclear Reactors," W. H. Chilton, 6.30 p.m.

Thurs., April 17.—YORKSHIRE BRANCH: Royal Victoria Hotel, Sheffield, "Some Structural Aspects of Nuclear Reactors," W. H. Chilton, 6.30 p.m.

INSTITUTION OF WORKS MANAGERS

Mon., April 14.—MANCHESTER BRANCH: Grand Hotel, Manchester, Annual General Meeting, 6.45 p.m.

Tues., April 15.—MERSEYSIDE BRANCH: Adelphi Hotel, Liverpool, Member's Evening, 6.30 p.m. ★ NORTHAMPTON BRANCH: Franklins Gardens Hotel, Northampton, "The Works Manager of the Future," G. J. West and F. Jenks, 7.45 p.m.

Wed., April 16.—LONDON BRANCH: Kent Room, Caxton Hall, Caxton Street, London, S.W.1, "The Application of Industrial Engineering Techniques (No. 4)," S. C. Brown; Discussion on "Industrial Engineering on the Shop Floor: Consultation, Suggestions, Incentive," 7 p.m.

Fri., April 18.—NOTTS AND DERBY BRANCH: Grandstand Hotel, Nottingham Road, Derby, Annual General Meeting, 7.30 p.m.

IRON AND STEEL INSTITUTE

Wed., April 16.—IRON AND STEEL ENGINEERS GROUP: Lecture Theatre, Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Modern Developments of the Ward-Leonard Principle and Applications in Steelworks," G. Ovens and C. A. Dodd, 10.30 a.m.; Discussion on "Electrical Maintenance in Iron and Steel Works," opened by J. T. Mills, 2 p.m.

Thurs., April 17.—IRON AND STEEL ENGINEERS GROUP: Lecture Theatre, Institution of Electrical Engineers, Savoy Place, London, W.C.2, "The Application of Remote Position Control to Screwdown Drives of Rolling Mills," L. N. Bramley, G. K. Steel and F. Seredynski; "The Application of Remote Position Control to Forging Presses," F. Seredynski, G. K. Steel and others, 10.30 a.m.; "Translator Control," W. N. Jenkins, 2 p.m.

JUNIOR INSTITUTION OF ENGINEERS

o-day, April 11.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Industrial Applications in Connection with Television," T. M. C. Lance, 7 p.m.

Mon., April 14.—SHEFFIELD AND DISTRICT SECTION: Livesey Clegg House, 44, Union Street, Sheffield, "Linear Measurement," F. E. Clarke, 7.30 p.m.

Fri., April 18.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "A Review of P.E.R.A. Activities," R. L. Hayward, 7 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, April 11.—Lecture Theatre, Mining Institute, Newcastle upon Tyne, "Recovery of Oil from Sludge in Oil Tankers," J. Lamb, 6.15 p.m.

PLASTICS INSTITUTE

Wed., April 16.—NORTH-EASTERN SECTION: 2nd Dining Room, Eldon Grill, Grey Street, Newcastle upon Tyne, Annual General Meeting, 7 p.m.

Fri., April 18.—MIDLANDS SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, 3, "Marketing Methods," A. W. Sherwood, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., April 15.—SECTION LECTURE: Library, 4, Hamilton Place, London, W.1, "The Problems of Vertical Take-off," C. T. Hewson, 7 p.m.

ROYAL SOCIETY OF ARTS

Mon., April 14.—John Adam Street, Adelphi, London, W.C.2, "An Introduction to Pre-stressed Concrete," G. W. Kirkland, 6 p.m.

Mon., April 21.—John Adam Street, Adelphi, London, W.C.2, "Systems and Uses of Pre-stressed Concrete," G. W. Kirkland, 6 p.m.

ROYAL STATISTICAL SOCIETY

Tues., April 15.—MERSEYSIDE GROUP: Royal Institute, Colquitt Street, Liverpool, "Stochastic Linear Programming," S. Vajda, 7 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., April 16.—CORROSION GROUP: 14, Belgrave Square, London, S.W.1, Annual General Meeting; "Corrosion Research and Its Industrial Background," W. H. J. Vernon, 6.30 p.m.

Thurs., April 17.—CORROSION GROUP: 14, Belgrave Square, London, S.W.1, Annual General Meeting of Education Panel, 11 a.m. ★ ROAD AND BUILDING MATERIALS GROUP: 14, Belgrave Square, London, S.W.1, "The Preservation of Building Stone," R. J. Schaffer, 6 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

To-day, April 11.—39, Elmbank Crescent, Glasgow, C.2, Symposium on "From Furnace to Mould," 6.45 p.m.

WOMEN'S ENGINEERING SOCIETY

Mon., April 21.—Central Electricity Authority Headquarters, Winsley Street, London, W.1, "Philosophy of Guided Missile Design," P. M. Chettle, 6.45 p.m.

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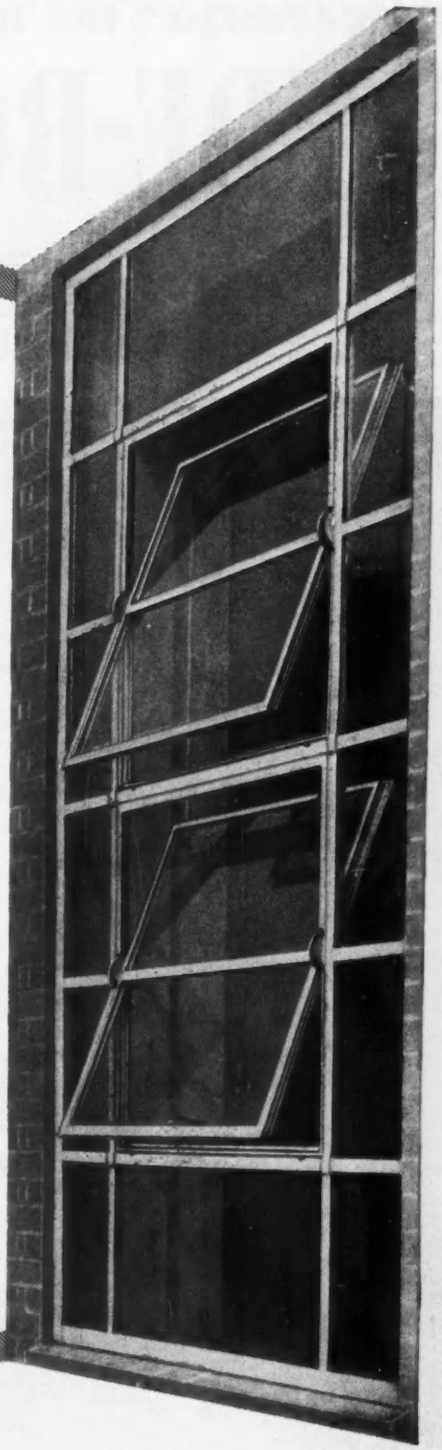

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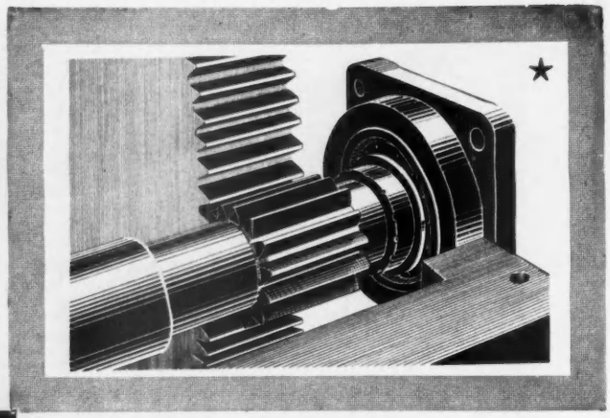

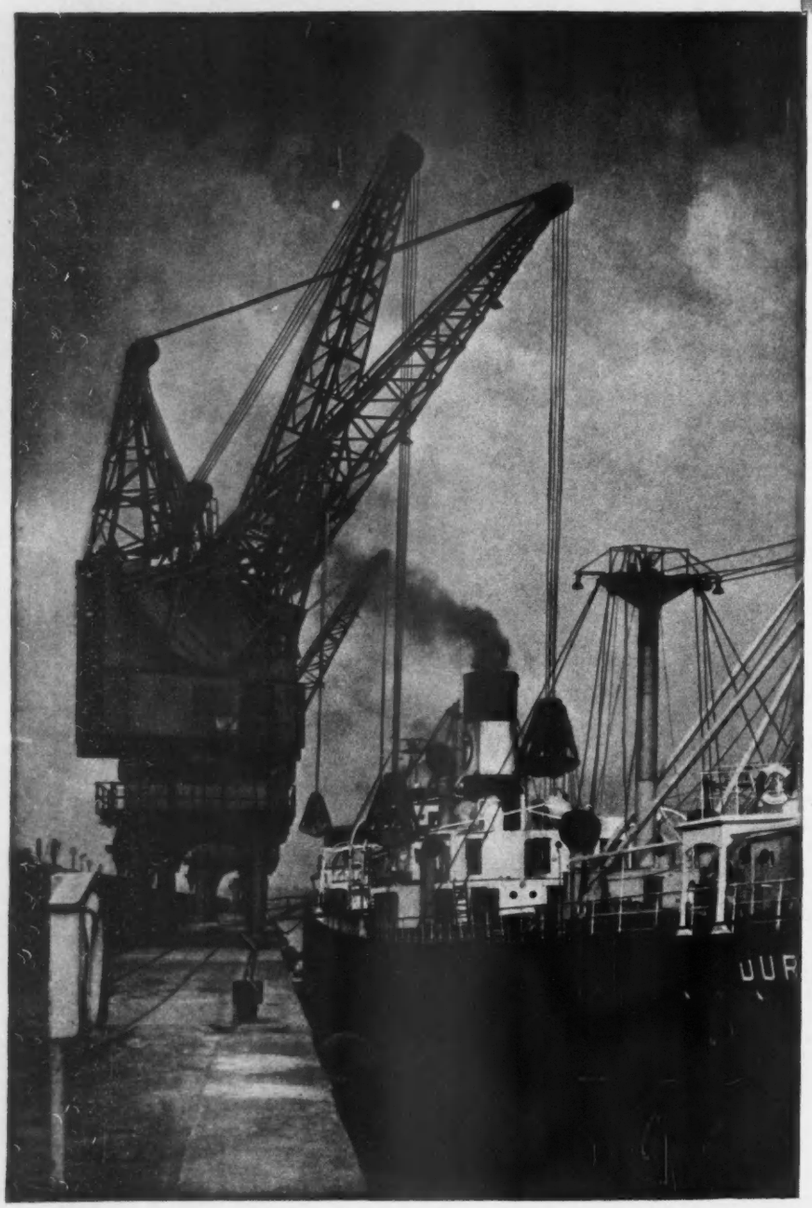

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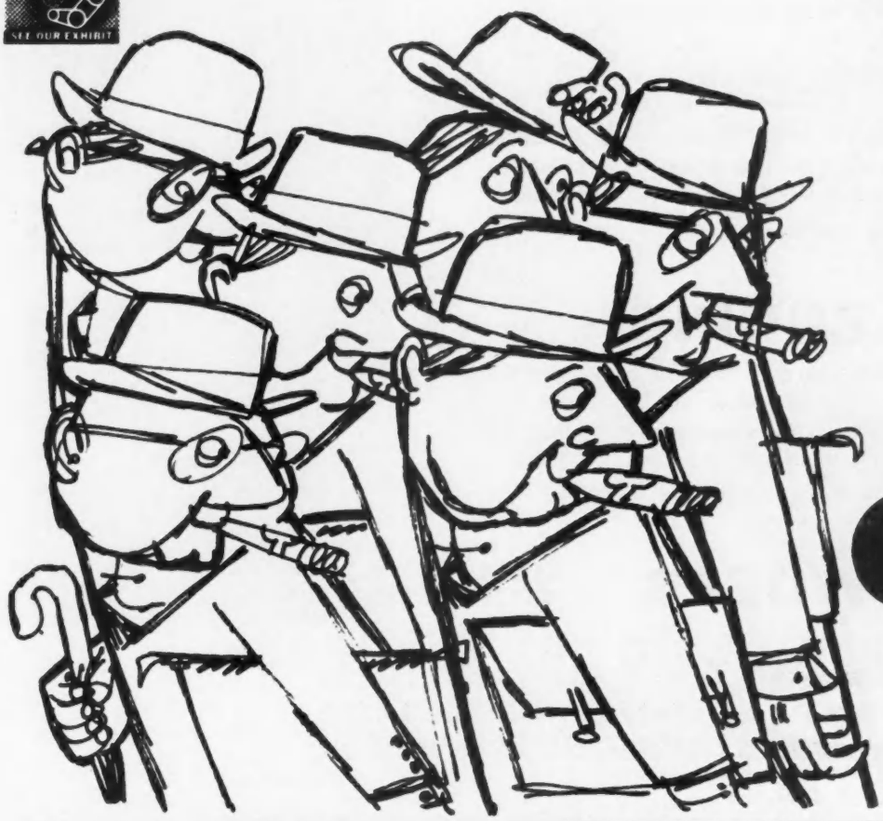

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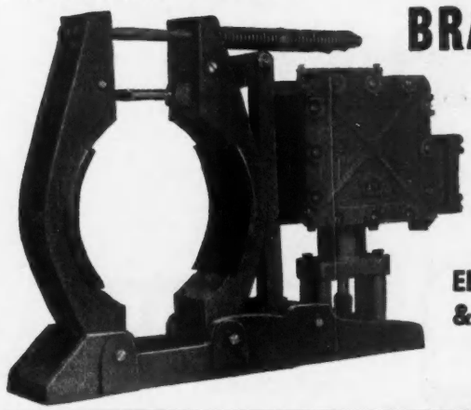

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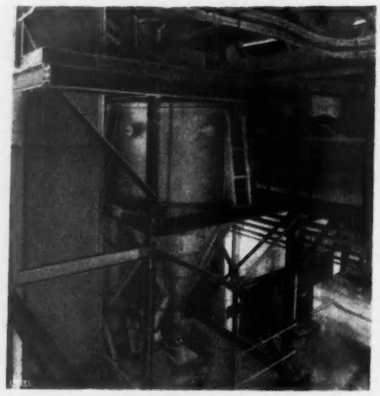

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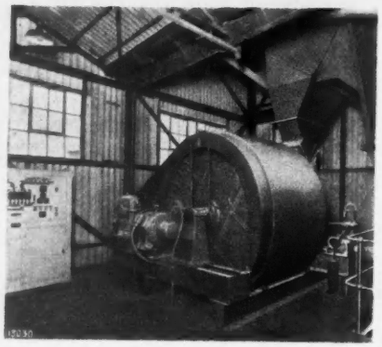

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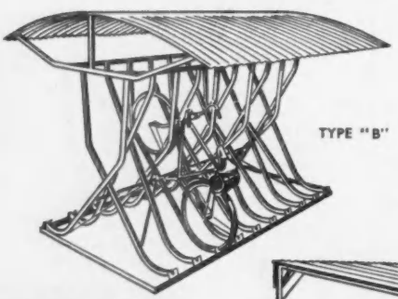

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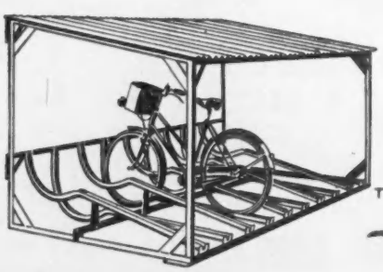

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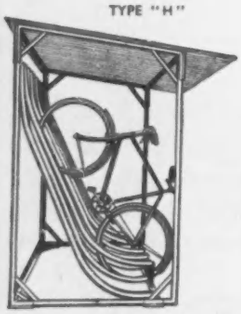

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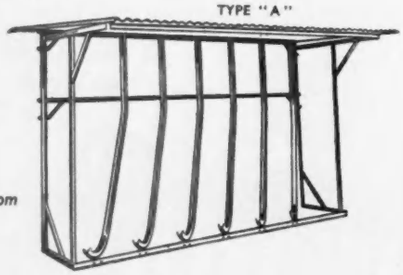

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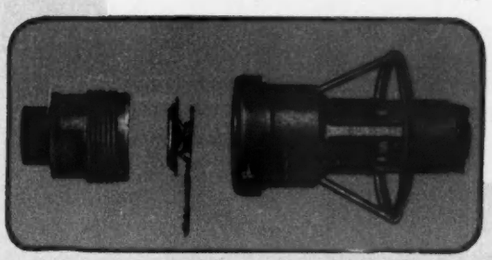

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Here's why!

- Ideal welding performance under all conditions
- Separate trouble-free excitation with no moving parts
- Fully laminated magnetic circuit giving rapid voltage recovery
- Automatic star/delta starter
- Large, easily accessible brush-gear giving excellent commutation
- Combined voltage and current regulation
- Armature, commutator and field coils readily replaceable even on site
- High electrical efficiency
- No series current divertor or resistor
- Minimum current and voltage drift
- Short overall length giving maximum shaft stiffness.

New engine-driven welder incorporating this generator design offers you:

- all the advantages of the MGB.400
- fully automatic idling
- electric starting
- Flexitor suspension available on running gear
- ample reserve of engine power at maximum current

For further details, specifications, etc. please write for our leaflet.

For better welding

and friendly service

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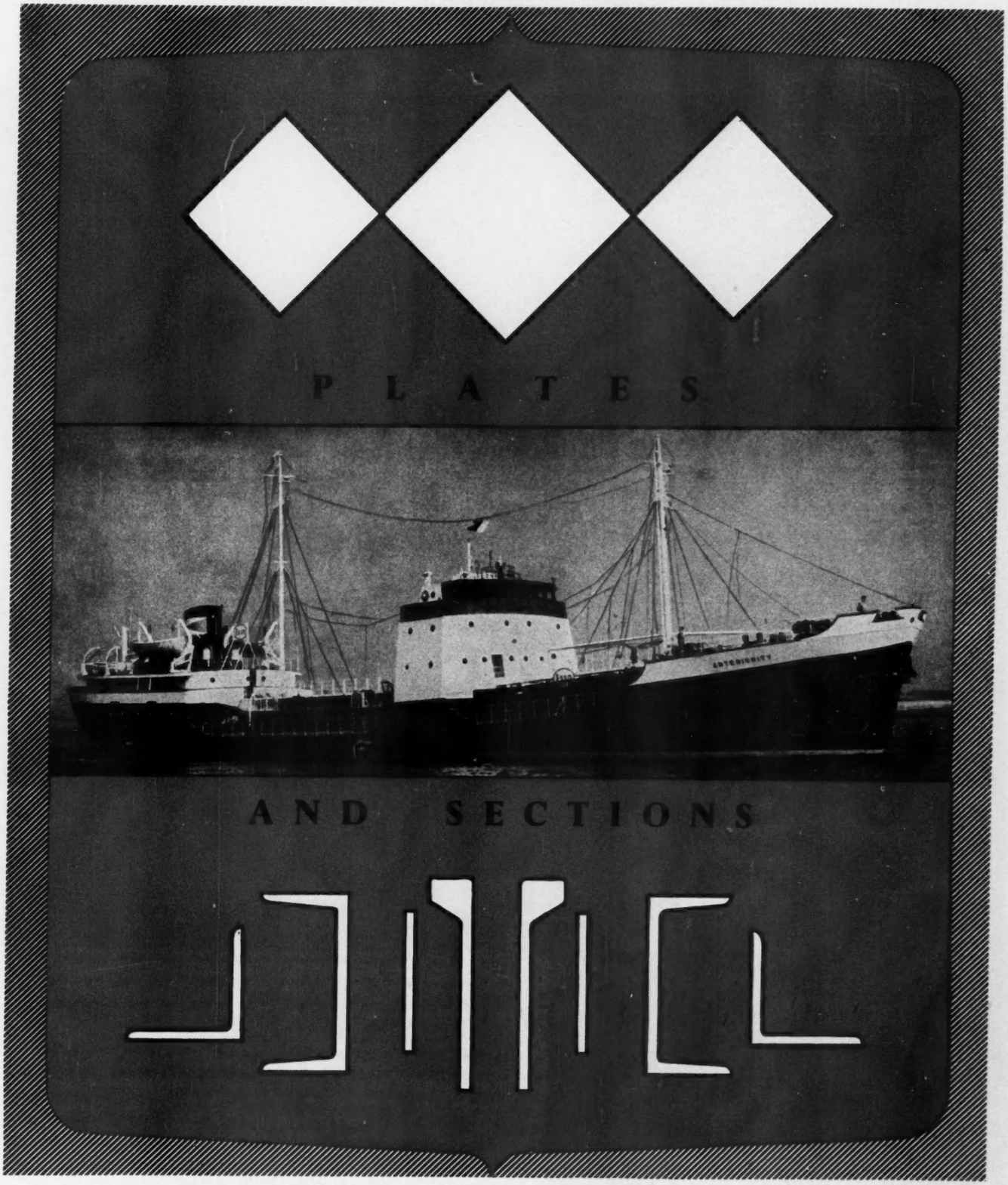
QUASI-ARC LIMITED · BILSTON · STAFFORDSHIRE



Substantial quantities of Appleby-Frodingham plates and sections were used in the construction of the oil carrier "Anteriority" (2250 tons gross), built by Goole Shipbuilding & Repairing Co. Ltd. for F. T. Everard & Sons Ltd., London.

THE UNITED STEEL COMPANIES LTD

APPLEBY FRODINGHAM STEEL COMPANY

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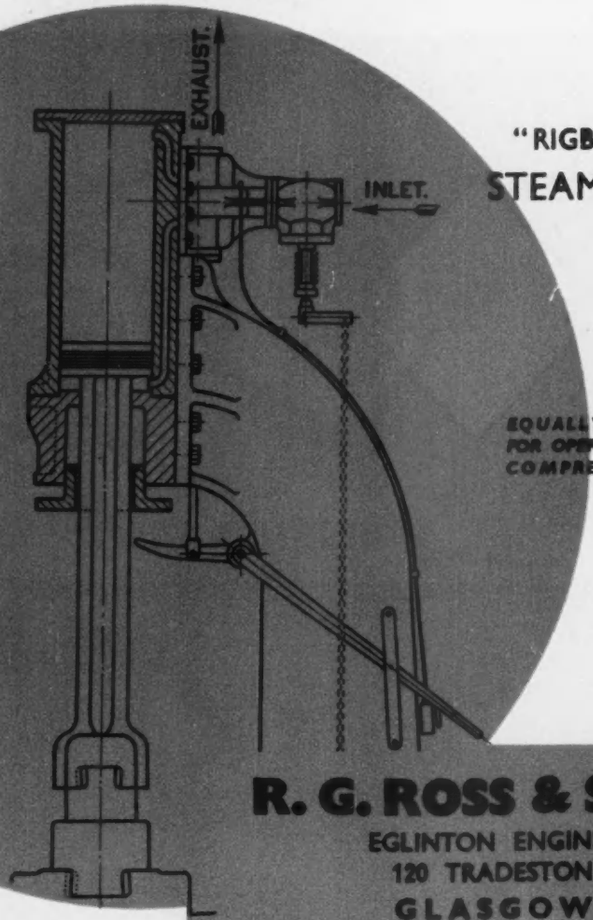
AF. 162

ROSS

THE
"RIGBY'S PATENT"
STEAM HAMMER

A phase of Railway Workshop activity abroad—showing "RIGBY'S PATENT" Hammer in operation.



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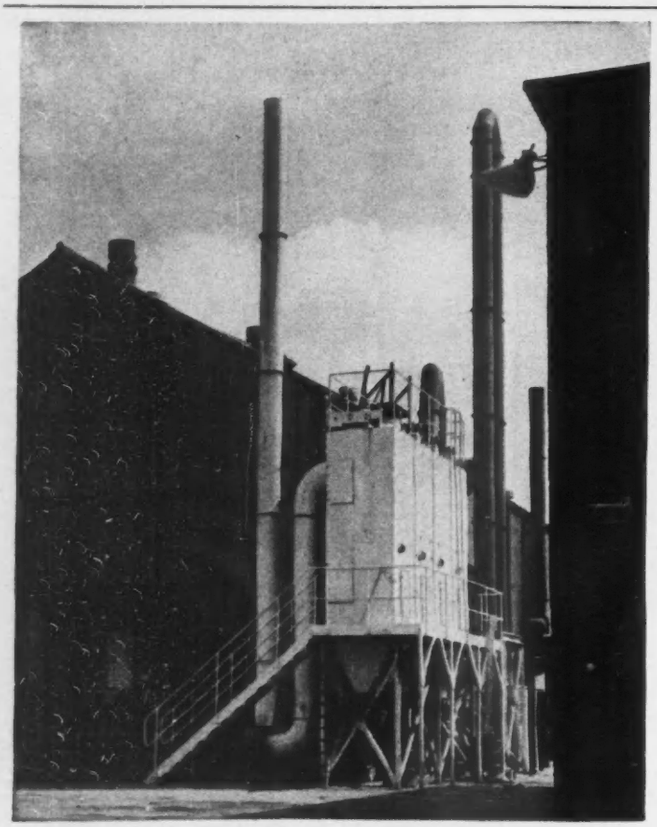

PONTIFEX
clears the air

The fully automatic Filter Plant, here shown in operation, was installed by Pontifex for British Lead Mills Ltd., at Welwyn Garden City, to clean the gases from an oil-fired rotary furnace treating non-ferrous metals. It was completed, and working, three weeks ahead of scheduled delivery date. The absence of visible discharge from the exhaust stack should be noted.

Dust and Fume Recovery

The Pontifex Service, using equipment which is wholly British in design and construction, can solve *your* Dust and Fume problem—quickly, economically and effectively. 'Unit Construction' speeds up and simplifies installation: the unique arrangement of valves and manifolds cuts down power consumption. You save both ways—in initial cost and in running expenses.

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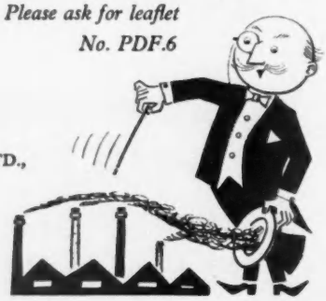
Please ask for leaflet No. PDF.6



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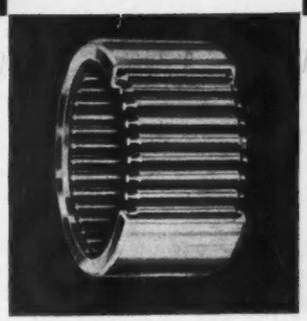
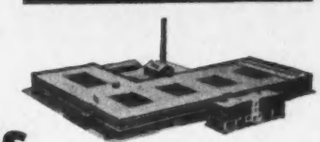
The savings add up fast!

Streamlining office procedures with modern business equipment pays off in hours and days saved. There are big savings, too, when Torrington Needle Bearings are used to eliminate friction in vital moving parts. For the purchaser, high-capacity Torrington Needle Bearings mean sensitive response, maintenance-free operation and long service life. For the manufacturer, they mean more compact anti-friction assemblies which contribute to simpler, less costly design; quicker, easier bearing installation and assembly; and lower unit cost per bearing. These savings add up fast, not only in office machines, but in all kinds of equipment used in the home, in business, in industry, on our highways and farms. Why not look into the savings possible in your own equipment? Your Torrington representative will be glad to show you the engineering "ways and means".





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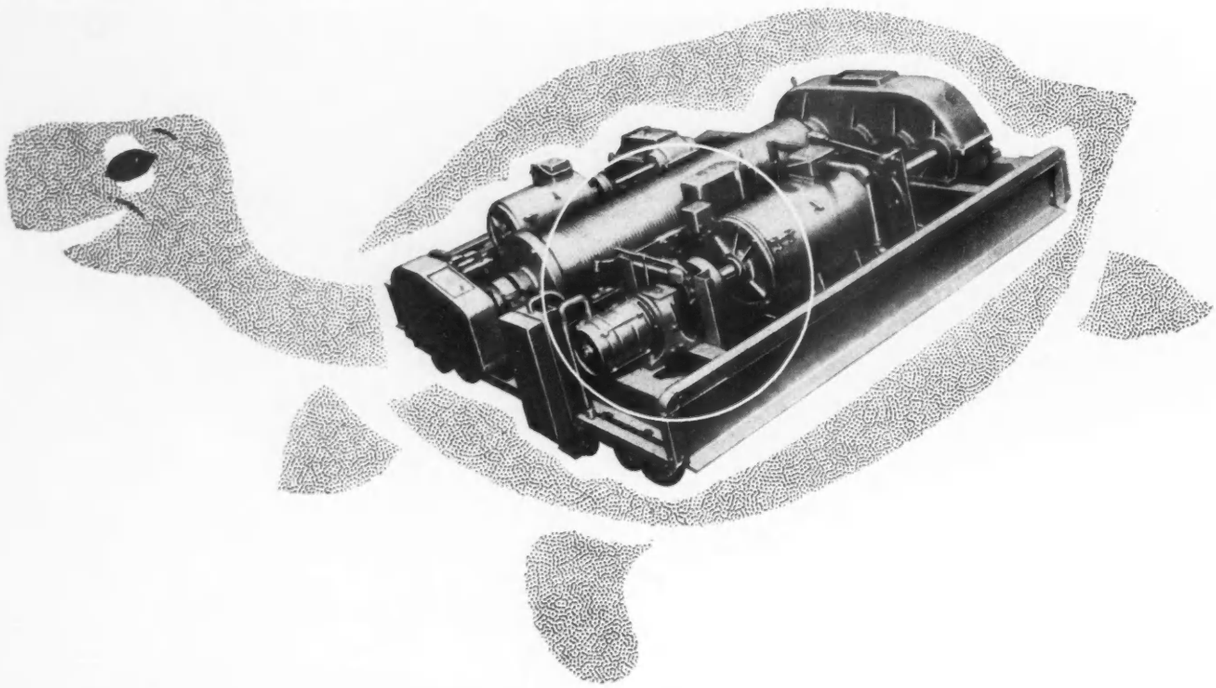
slowly but surely . . .



Slomax Creep-Speed Control

This system was developed to meet the need for a controlled creeping speed for all motions of cranes on A.C. supply where precise slow-speeds are required.

The success of this well-tried system, proved under arduous conditions, lies in its extreme simplicity.

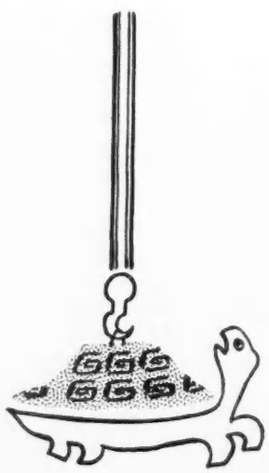
The device is entirely automatic and fool-proof.

The main motor is not energised when the creeping speed is in operation.

The operating circuits being electrically inter-locked, it is impossible for the main motor and the Slomax motor to operate simultaneously.

Slomax control permits an unlimited ratio between creeping and normal speeds, and whilst ten to one is usual, a ratio of fifty to one is not uncommon for specialised duties.

A further advantage is that where precise creeping speeds are required for specialised operations, the Slomax control will ensure a predetermined creeping speed, irrespective of the load on the hook.



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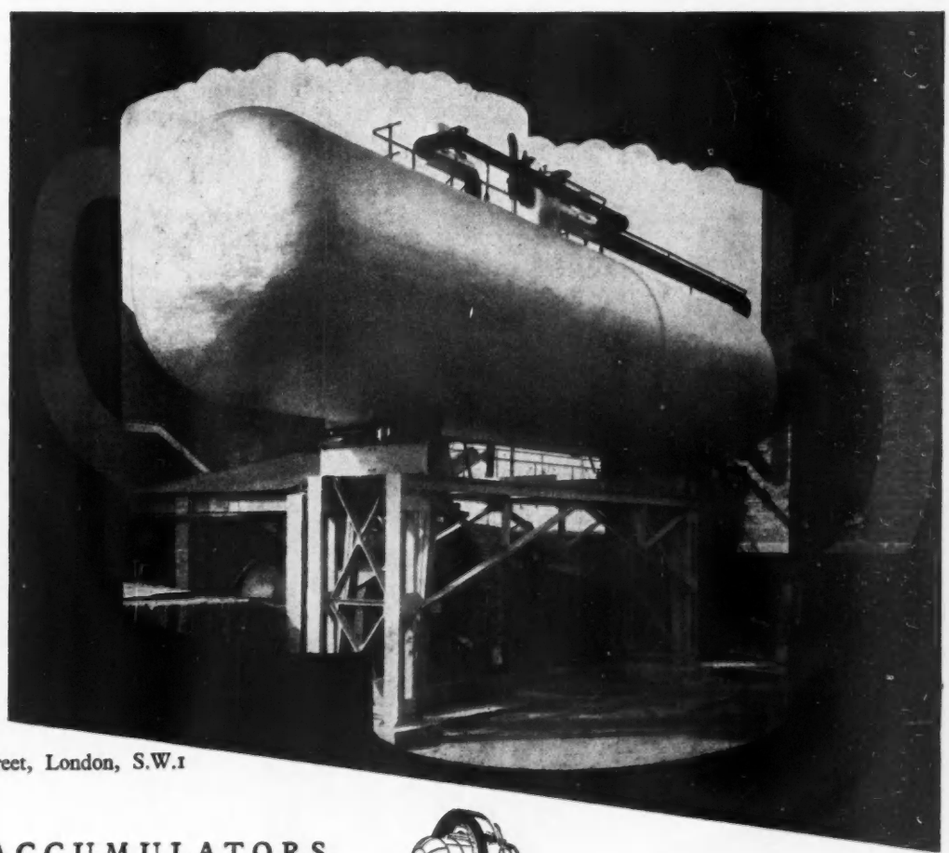
Sharp Control Gear Ltd., Lount Works, Ashby-de-la-Zouch, Leicestershire. *Telephone: Ashby 422*

Steam storage in a brewery



A Ruths Steam Storage Accumulator takes care of the fluctuating steam demands at the Wellpark Brewery of Messrs. J. & R. Tennent Ltd., Glasgow.

The shell is 11′ 0″ in diameter and 50′ 0″ long. The accumulator works over a pressure range of 150 to 70 p.s.i. giving a reserve of 11,250 lbs. of steam which is instantaneously available to meet all process demands in excess of *steady* boiler output.

Steam users in **all** industries can overcome problems arising from peak steam demands by installing Ruths Steam Accumulators. Please consult:—

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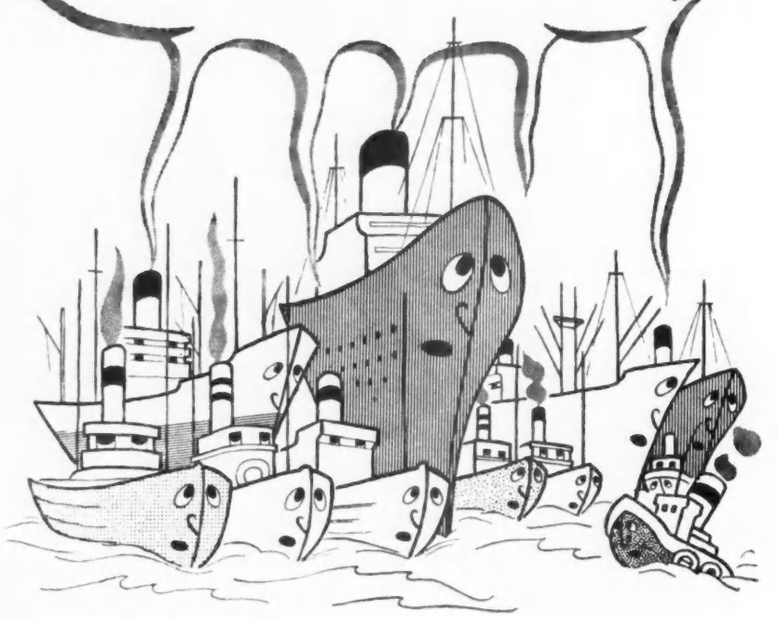
87 HELEN ST GOVAN GLASGOW
(Prop.: The Steel Company of Scotland)

What we want are L & C piston rings!

With acknowledgements to Watney, Combe, Reid & Co. Ltd.



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★ ANY TYPE SECTION
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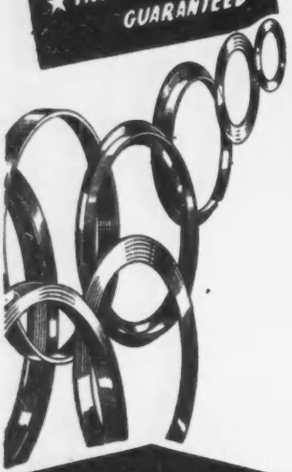

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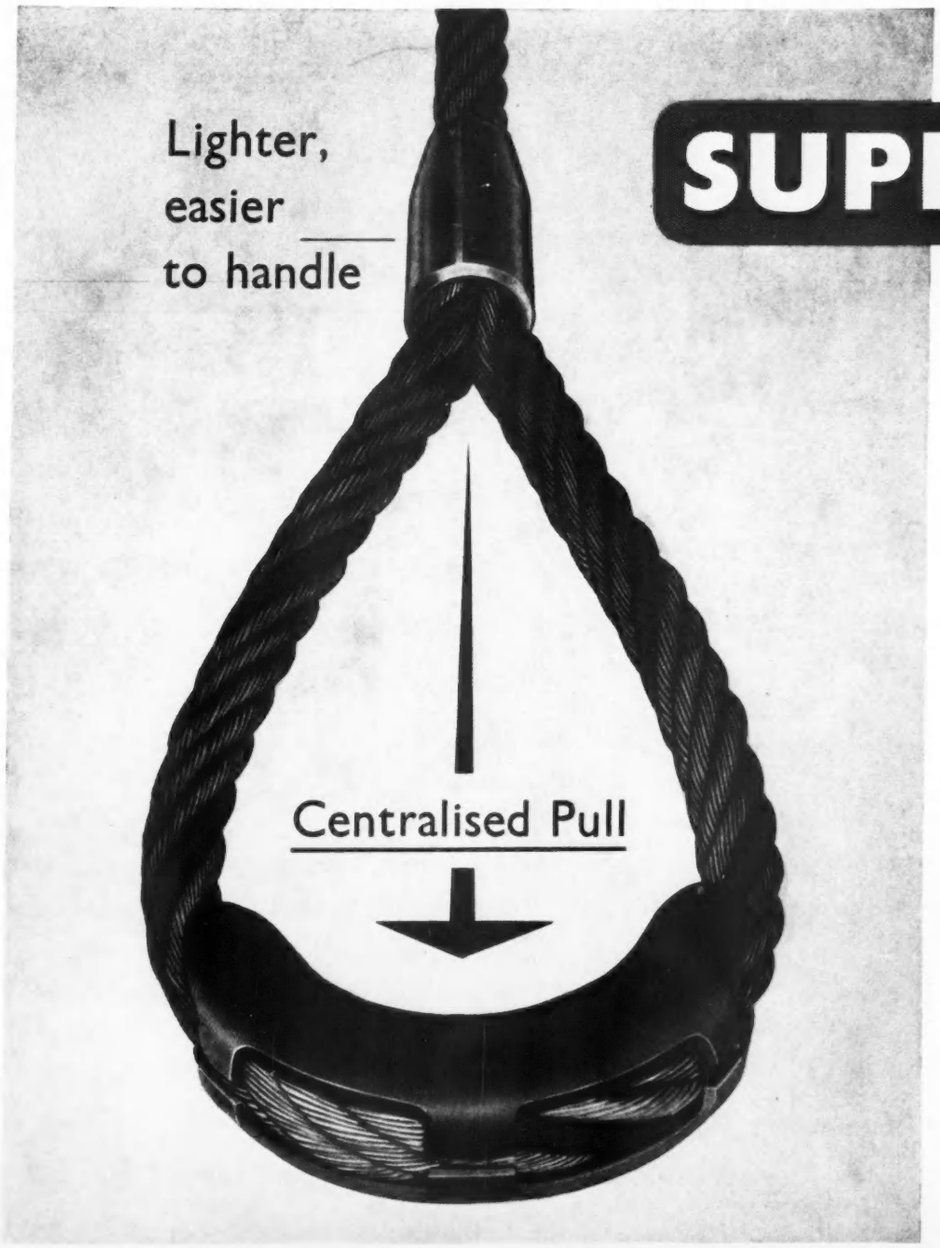


SUPERLOOP

Patent pending

a slimmer, safer mechanical splice

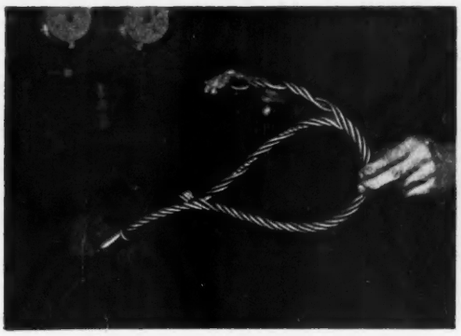
British Ropes Limited have evolved a new type of wire rope sleeve to overcome the drawbacks of other mechanical splices.

The main advantages of this new process, SUPERLOOP, are a safer mechanical splice, a slimmer sleeve, and a *true centre pull*. The sleeve, made of a specially approved steel, is closed over the tails of a Flemish Eye splice, making SUPERLOOP the lightest, slimmest and easiest to handle. It is at least as strong as a well made hand splice, and practical tests show it to be particularly ideal for the hard-worked sling. The smooth exterior of the sleeve, and its small dimensions mean that SUPERLOOP can be employed in many applications where more bulky hand and mechanical splices are impracticable. SUPERLOOP is concentric with the rope because of the Flemish Eye which is incorporated. A specially developed fitting, known as a SUPERLOOP STIRRUP, is available to protect the bearing of the eye from wear.

The development of SUPERLOOP was achieved only by intensive research and exhaustive tests backed by the wide knowledge and experience of the manufacturers.

HANDS ARE SAFE WITH SUPERLOOP

During the six months' operational tests throughout the country, SUPERLOOP users report *complete freedom* from the hand injuries normally experienced with bare wire ends and broken wire servings.

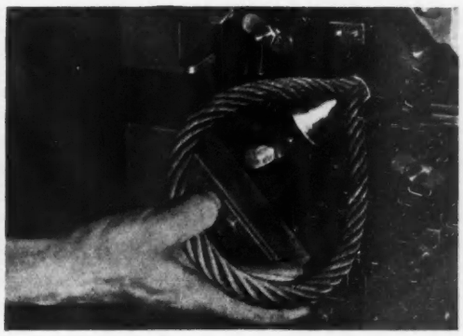


FORMING THE LOOP

The secret of SUPERLOOP's true centre pull —a Flemish Eye is hand spliced and this alone gives a strength in excess of the Safe Working Load even before *the sleeve is fitted.*

FITTING THE SLEEVE

The steel sleeve is fitted neatly over the tails of the splice and is tapped into place entirely covering the wire ends.



PRESS CLOSES THE SLEEVE

Specially designed Dies permit comparatively low pressures to be used, eliminating any serious damage due to crushing.

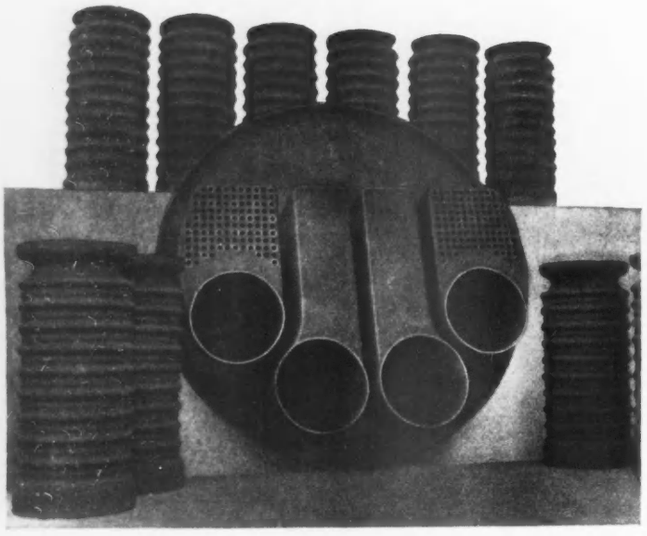
SUPERLOOP in conjunction with Blue Strand Preformed Rope gives you the perfect sling.

Developed by **BRITISH ROPES LIMITED** *Doncaster*

Wire Rope Sales Offices at London, Liverpool, Birmingham, Glasgow, Cardiff, Gateshead, Hull, Southampton etc.

H-W.57

RIGHT ON THE MAP



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AUTOMATIC WATER STRAINERS
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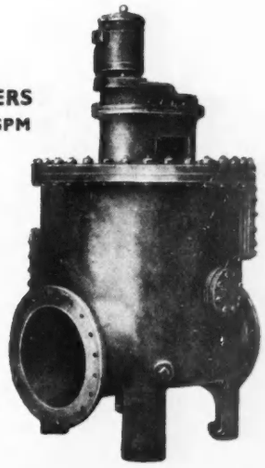

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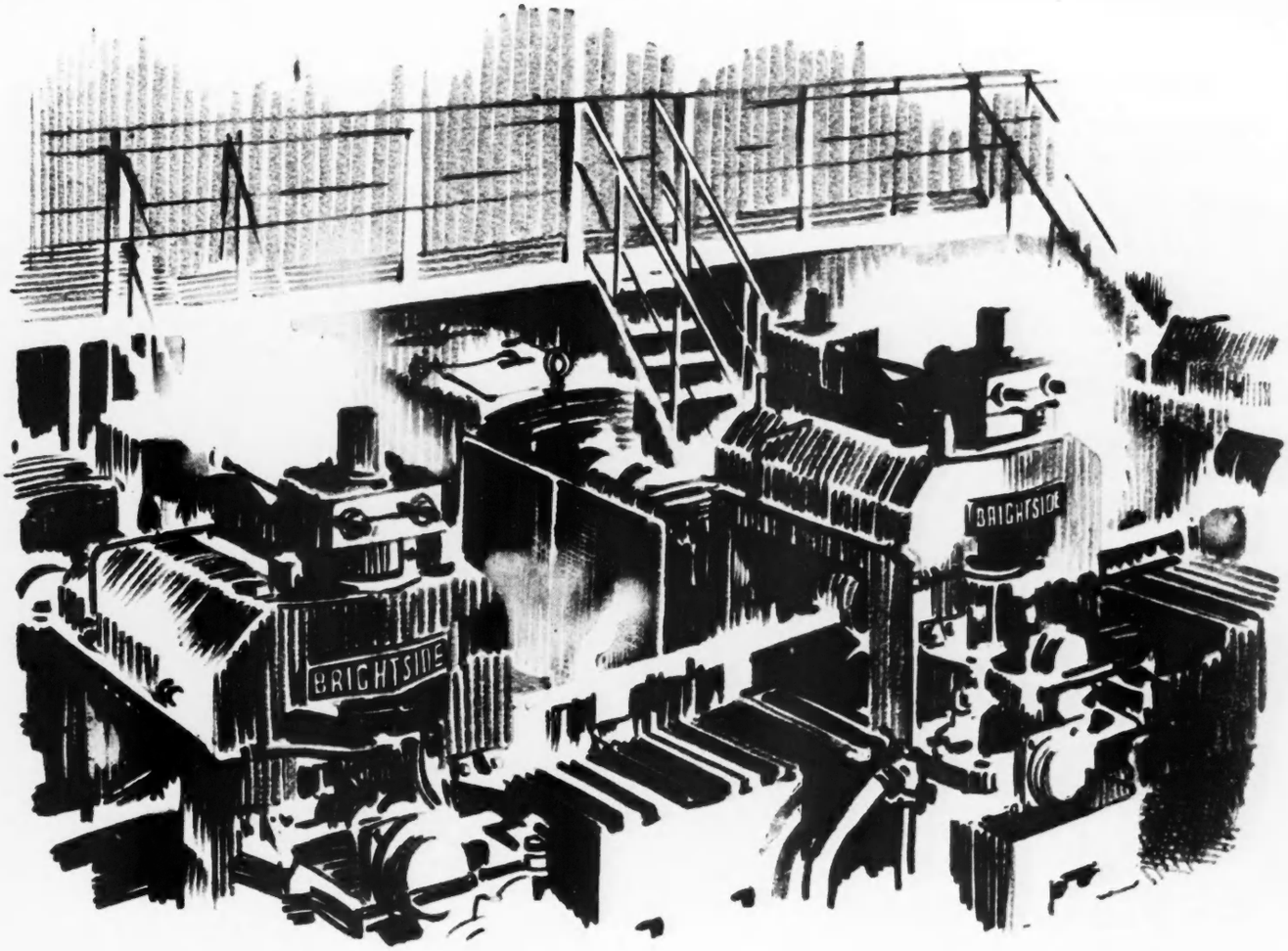

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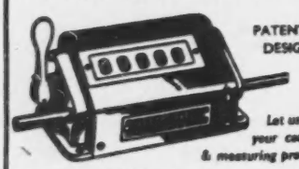

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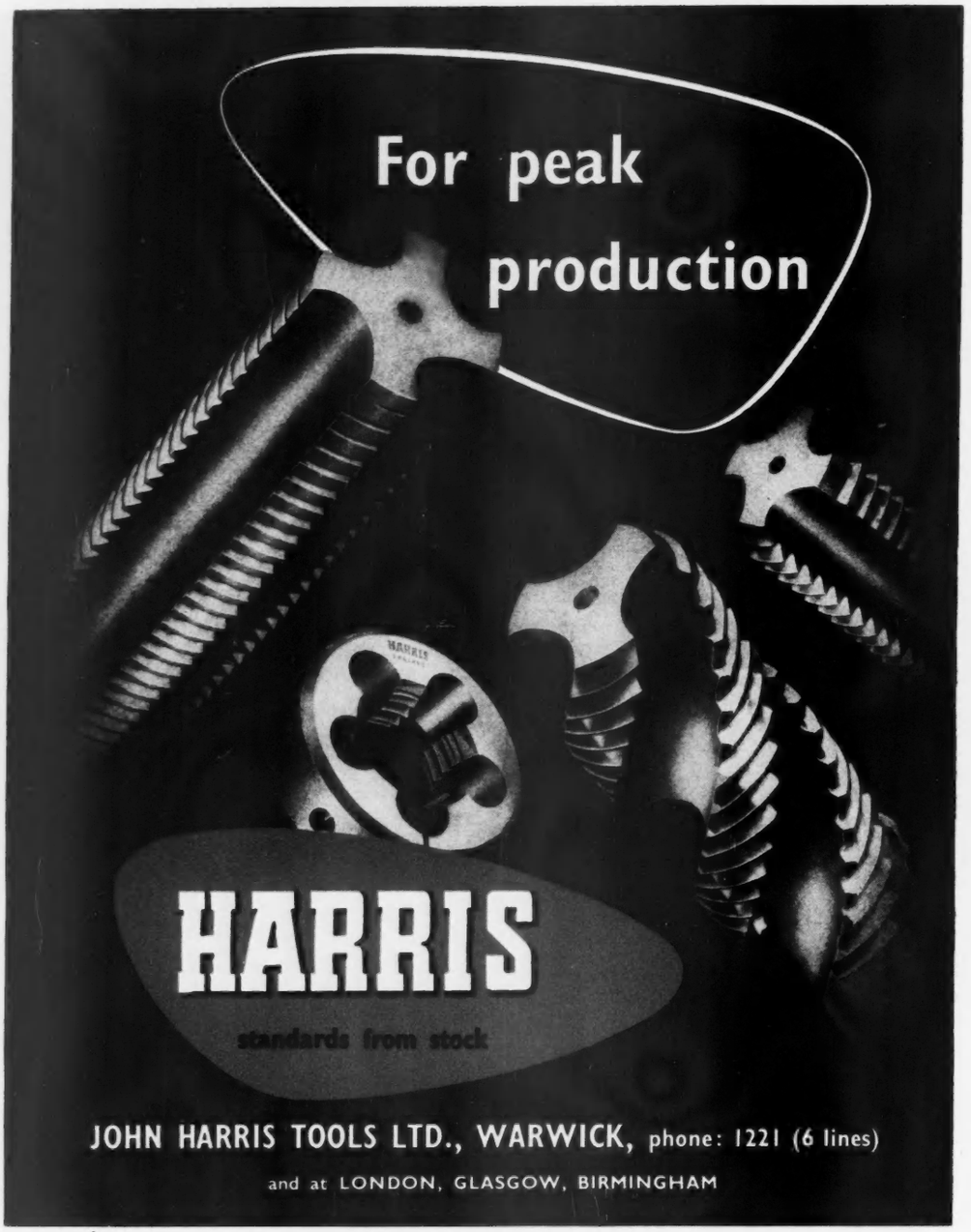

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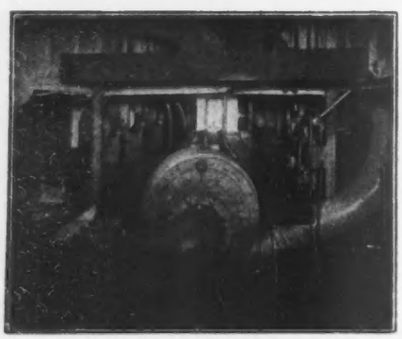
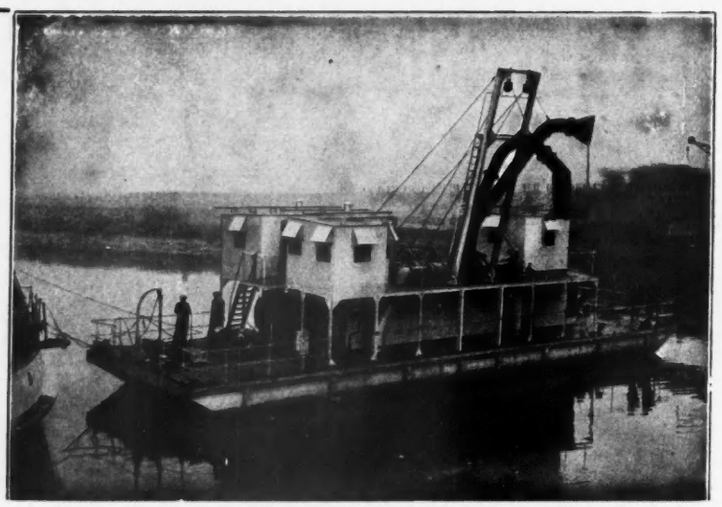
New Buckets, Links, Pins, Gearing, etc., supplied for existing Dredgers.



Main Machinery Room showing High Efficiency Pump in foreground, with quick release bean for rapid inspection of pump.



All Electric Reclamation Pumping Plant "Larubi" Constructed for the Anglo-Iranian Oil Co. Ltd. Dimensions: 74 × 22 × 7 feet. Pumping capacity: 200 tons of mud per hour through 500 feet of shore pipe to a height of 30f eet above low water.

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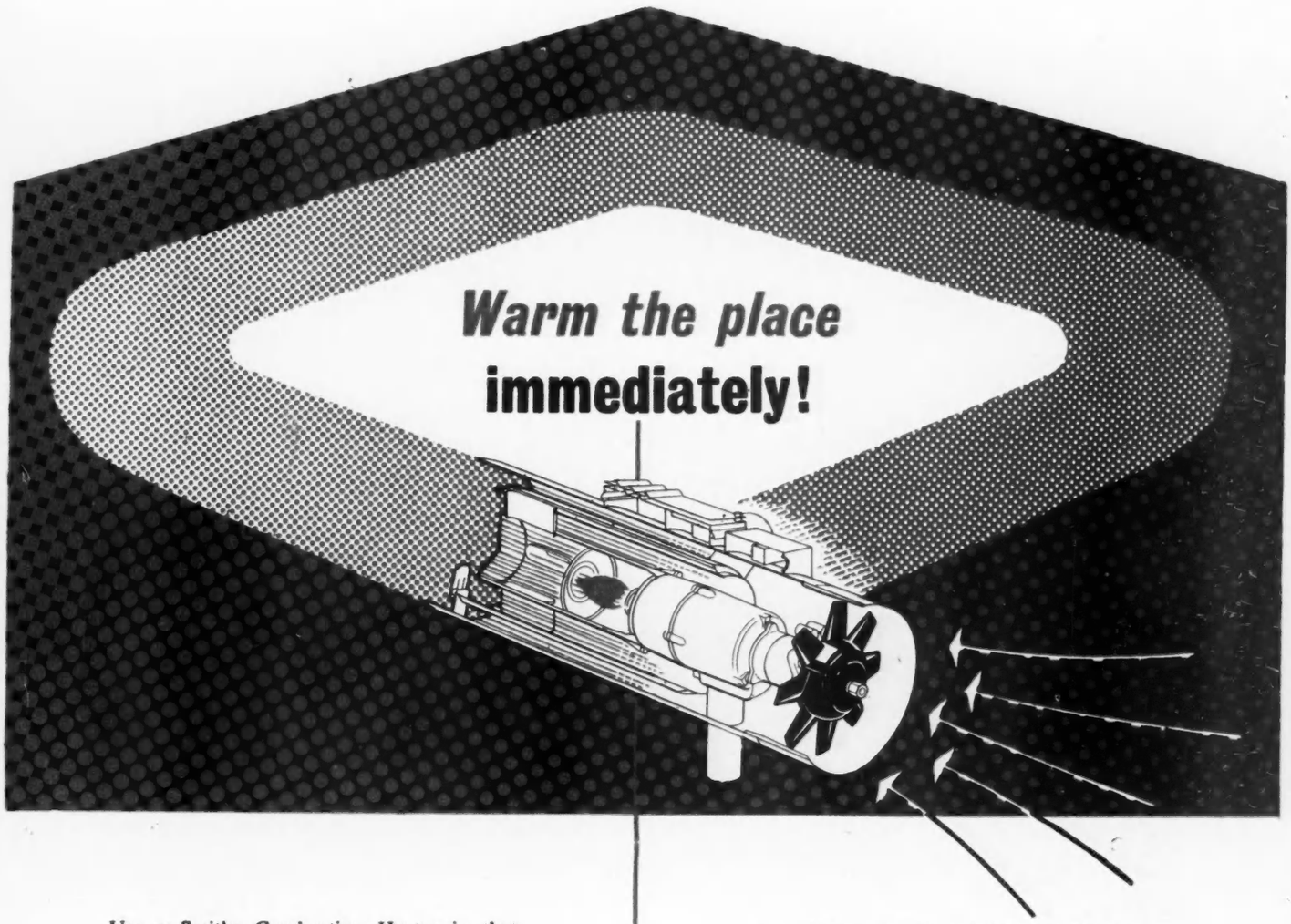

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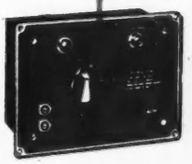

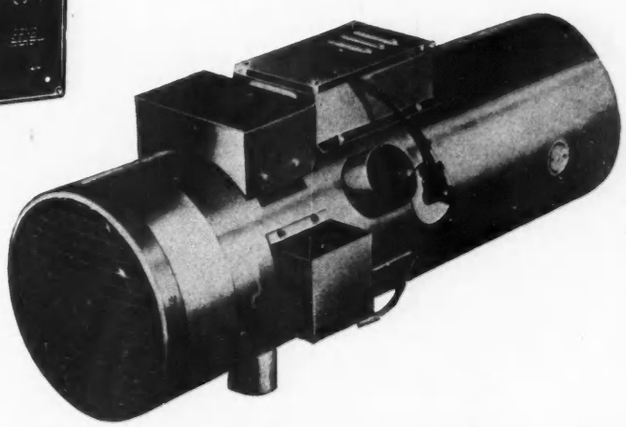

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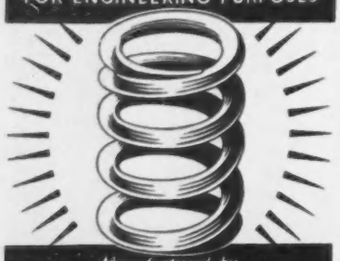

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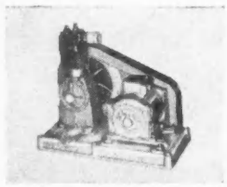

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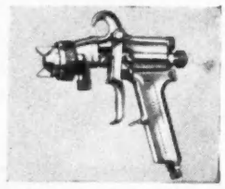

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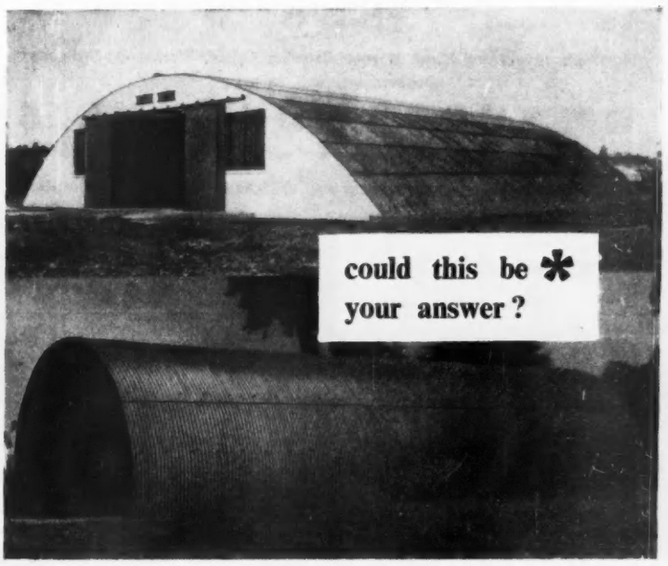

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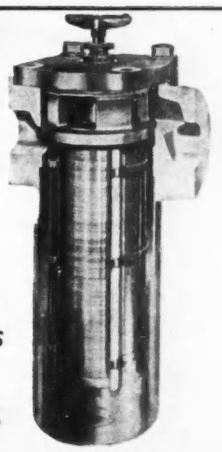

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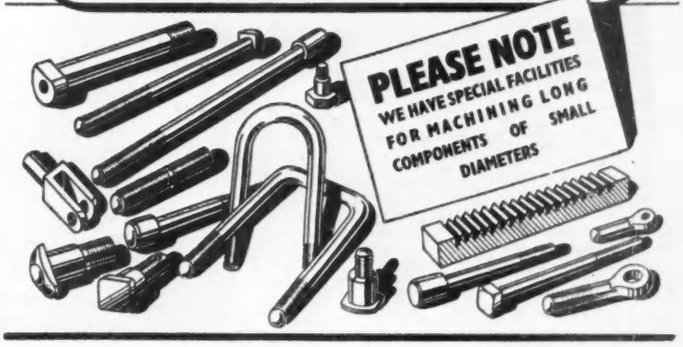

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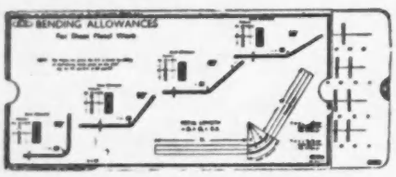

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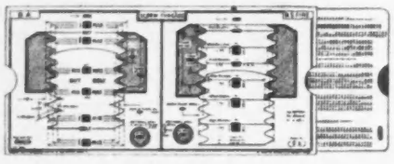

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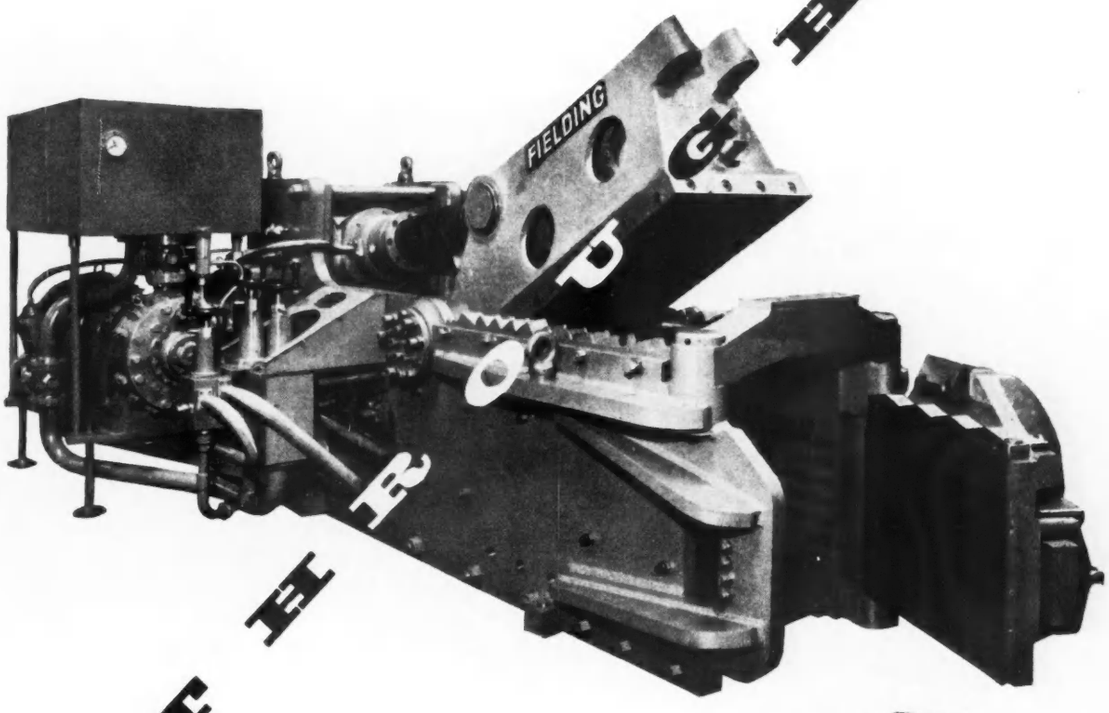

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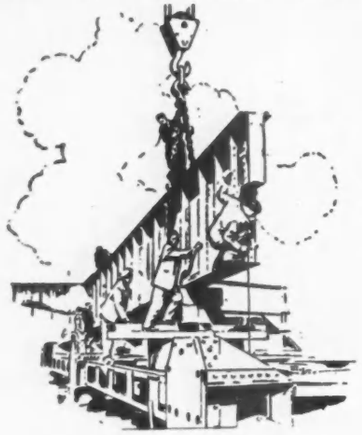

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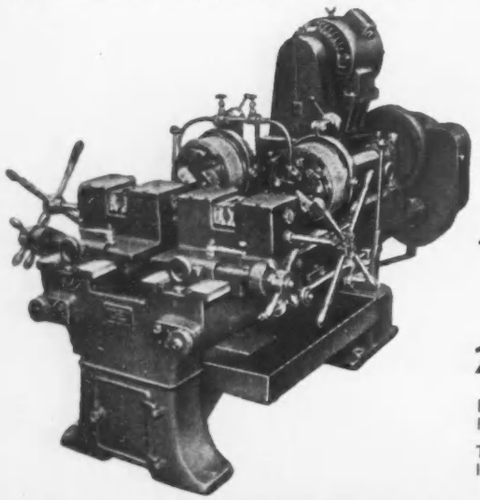

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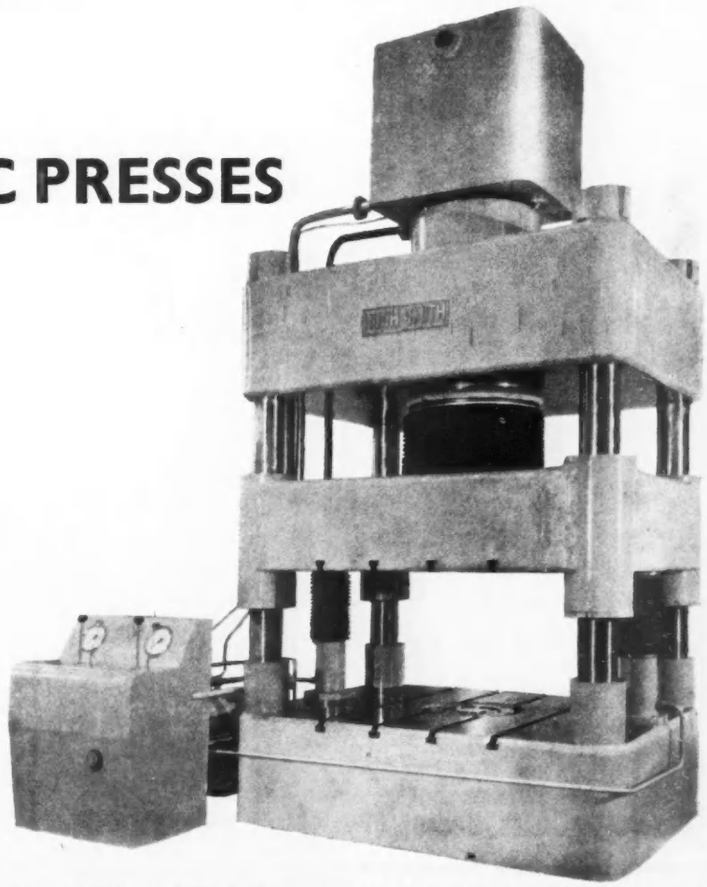

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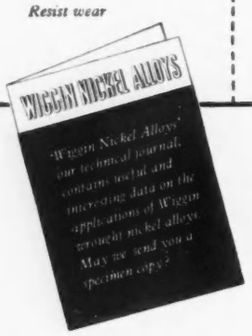
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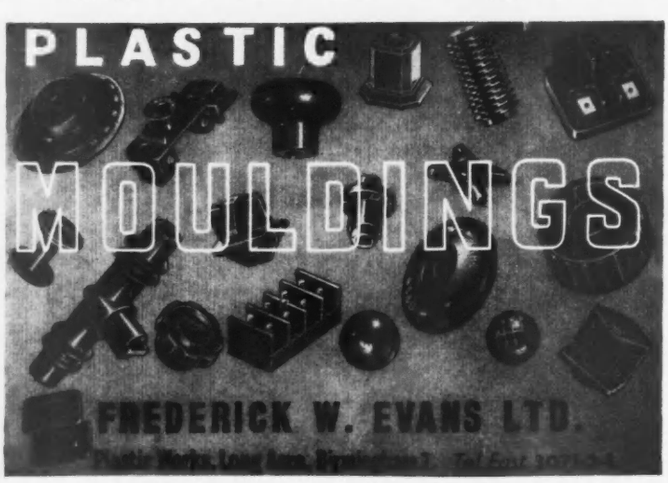

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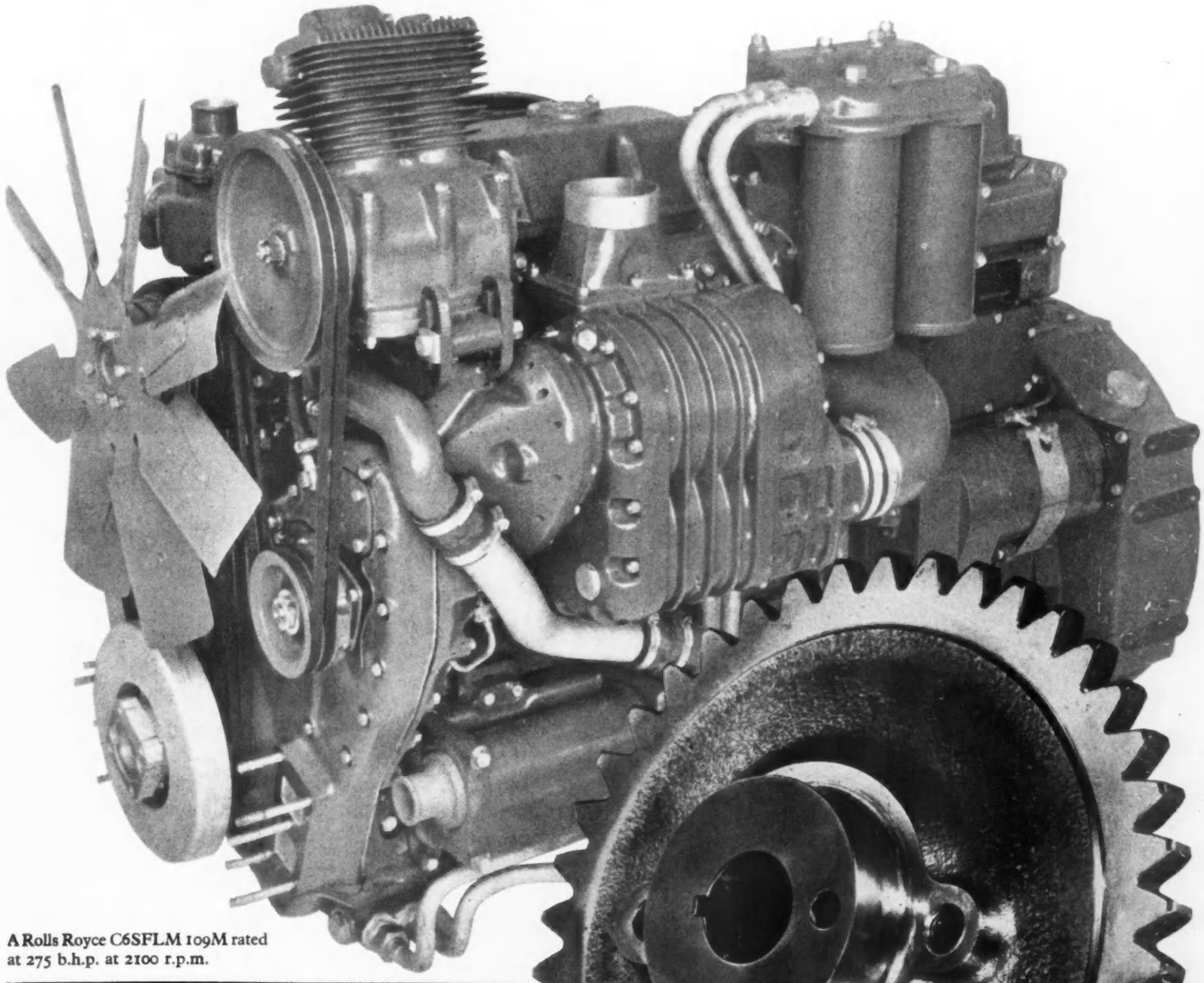

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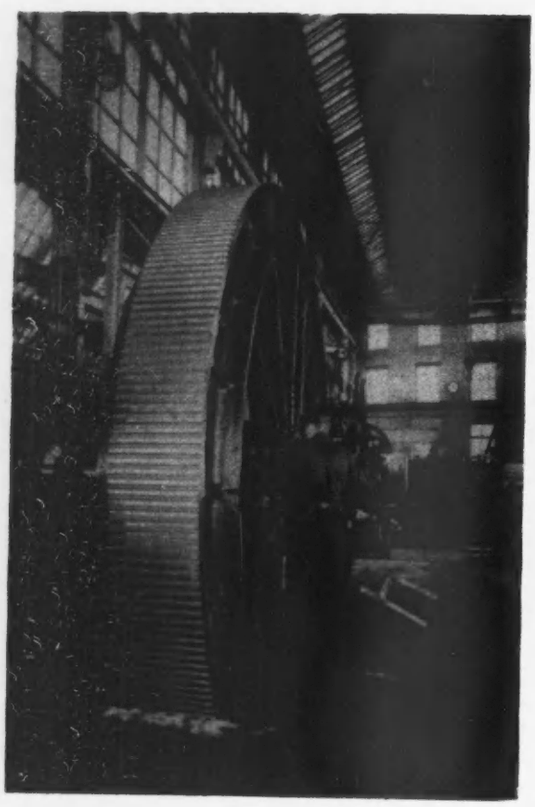

CROFTS MACHINE CUT GEARS

for every duty—gears up to 186" diameter
32" face width and 6" CP

Publication 5519

- Our own high grade castings and precision gear cutting: one responsibility, one high quality
- Special fabricated gears also built to the highest standards
- Full stock range
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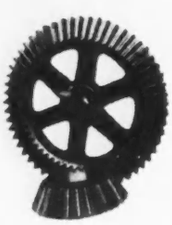
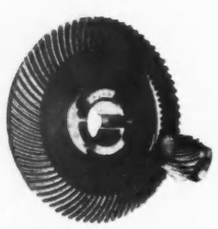
  Larger sizes at shortest notice

Double Helicals up to 186" diam. 32" face, 6" CP



Bevels and Mitres up to 72" diam. 14" face, 4" CP



Spiral Bevels up to 60" diam.

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POWER TRANSMISSION ENGINEERS
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Telephone: 65251 (20 lines) *Telegrams:* "Crofters, Bradford Telex", Telex 51186

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for ball, rod and tube mills
Gears up to 186" diameter 30" face width and 6" CP

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Crofts Kiln drive at a South African Cement Works

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Worms up to 12" diam. and 3" normal pitch
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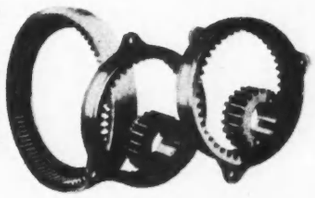
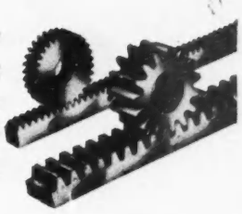
Internals up to 96" diam. 6" face, 1½ DP smaller diams. down to 20 DP



Racks and Pinions up to 5" pitch and any length



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From 22 to 66 KV

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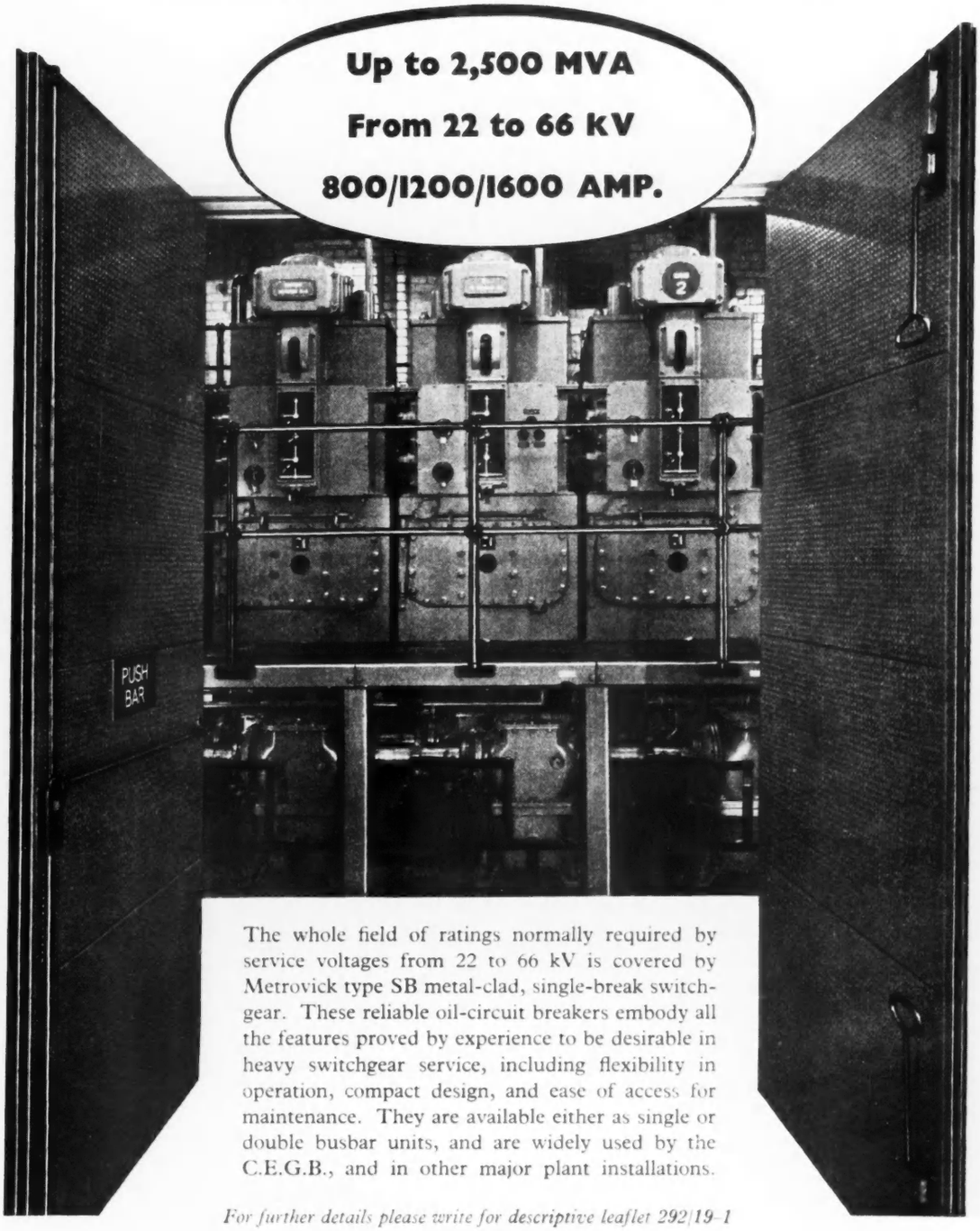

The whole field of ratings normally required by service voltages from 22 to 66 kV is covered by Metrovick type SB metal-clad, single-break switchgear. These reliable oil-circuit breakers embody all the features proved by experience to be desirable in heavy switchgear service, including flexibility in operation, compact design, and ease of access for maintenance. They are available either as single or double busbar units, and are widely used by the C.E.G.B., and in other major plant installations.

For further details please write for descriptive leaflet 292/19-1

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LEADING SWITCHGEAR PROGRESS

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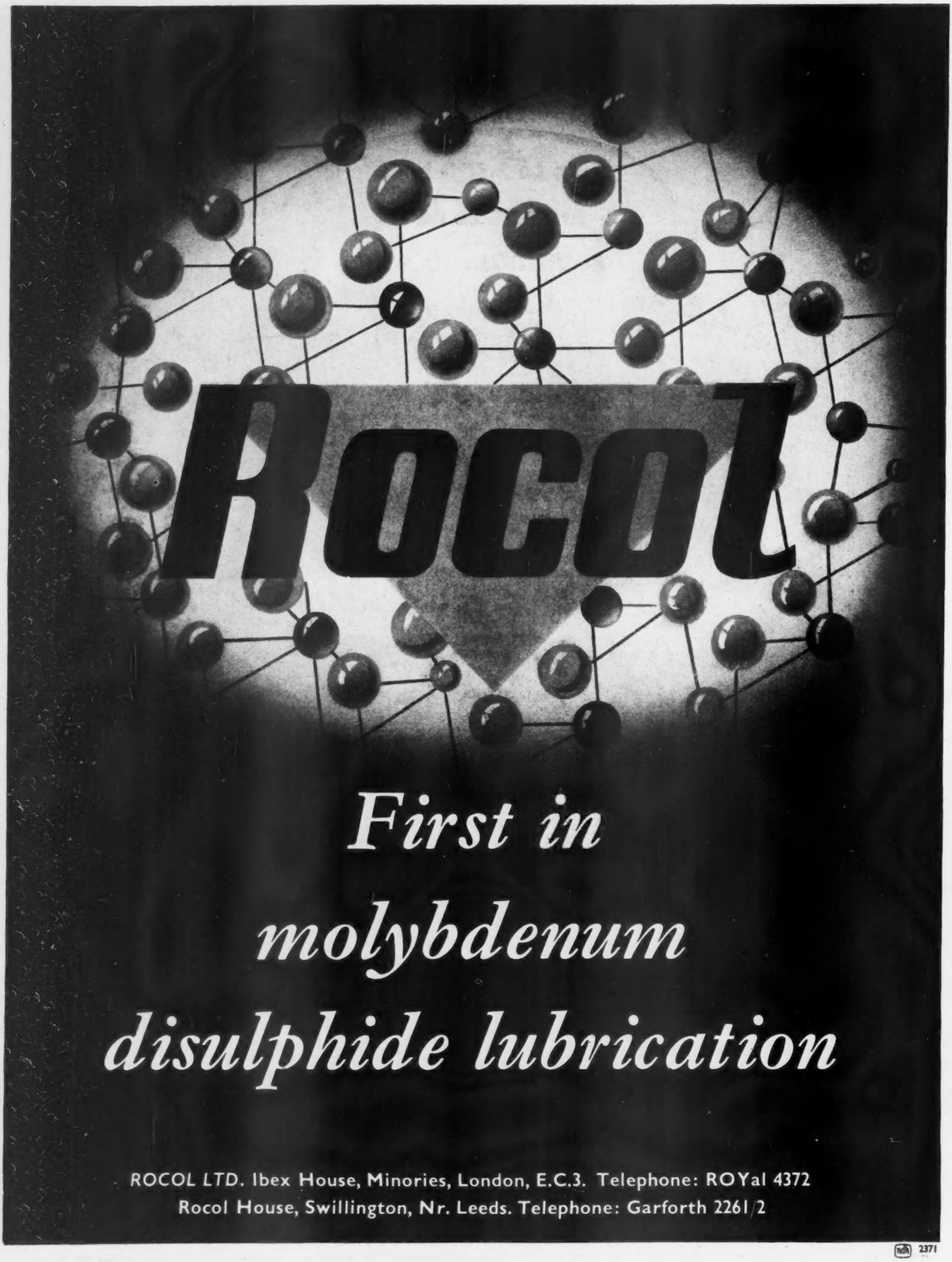
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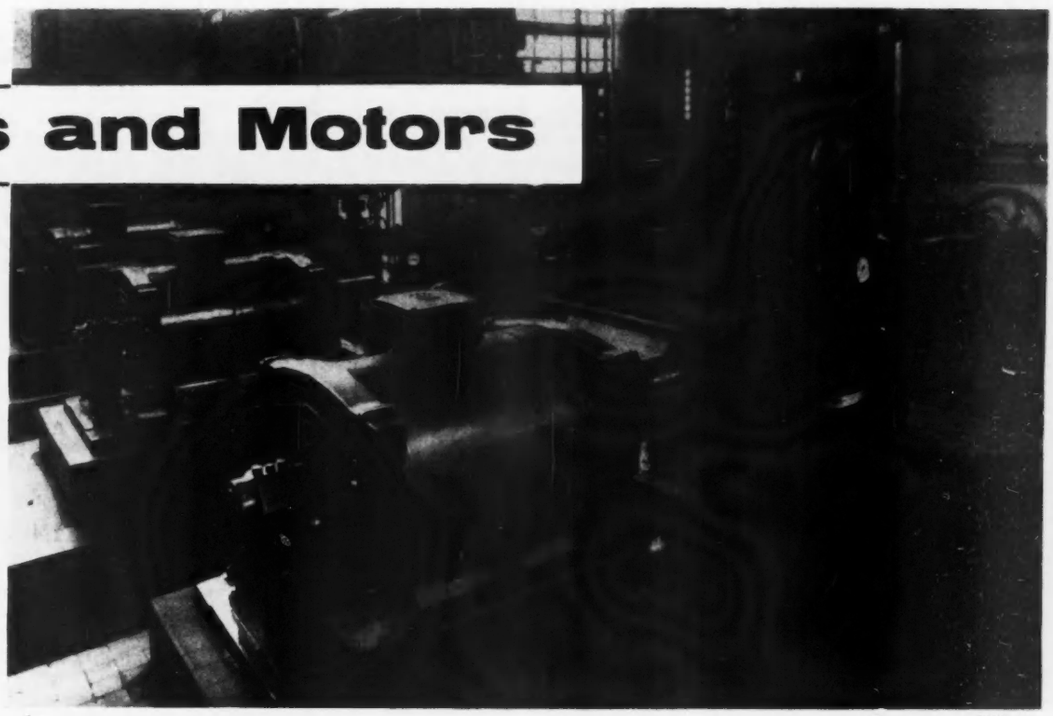
Pumps and Motors



795-2

Three Mather & Platt high-speed Plurovane pumps working in conjunction with air-pressurised hydraulic accumulators in a large steel works. Each pump is capable of dealing with 300 g.p.m., 835 p.s.i. and is driven by a Mather & Platt drip-proof squirrel-cage induction motor, rated at 275 b.h.p., 2750 v., 2930 r.p.m., direct-on started with a low starting current. The sets are arranged for automatic operation.

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Standard and non standard ratios available from 5 : 1 to 50 : 1.

3", 4", 5", 6" and 8" Worm Gear Centres.

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3" WORM GEAR RATIO 25:1 fitted with a 1½ H.P. Motor.

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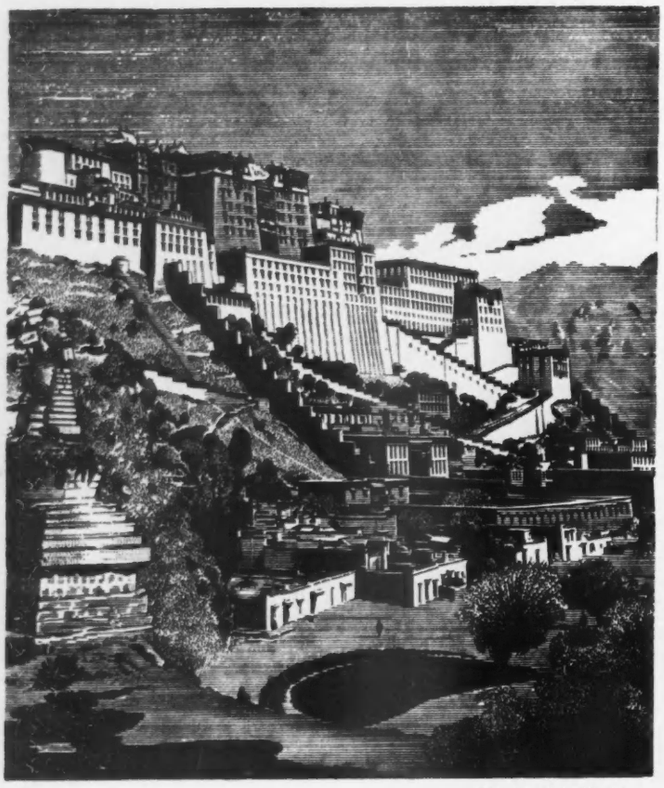
THE DALAI LAMA'S PALACE, TIBET



Wonders of the World

INSPIRED by the fifth Dalai Lama, the construction of this imposing palace at Lhasa was commenced in the seventeenth century. The Dalai Lama died before it was completed and his death was concealed from the populace by the regent for some sixteen years. Surmounting the palace are golden-roofed shrines of deceased Dalai Lamas. Thousands of pilgrims still bring gifts to the present ruler and the palace is said to store rich treasure.
The Wonders of the Modern World will be chronicled by posterity and will reveal the indispensable contribution of steel tubes to these achievements.

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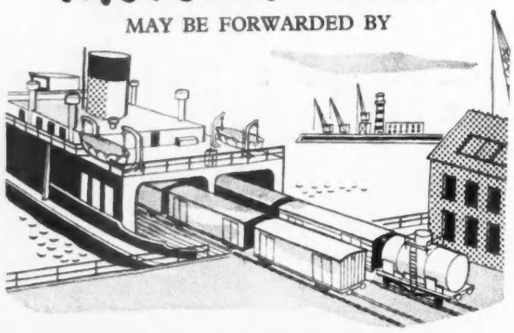

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Where strength and the passage of maximum light and ventilation is required . . .

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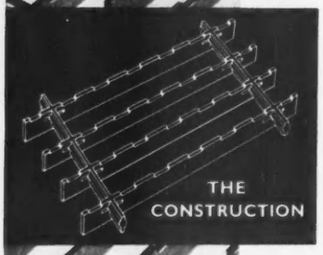

The design of "OVALOCK" ensures that loads, either concentrated or distributed, can be carried with an ample factor of safety, and what is more, *it can be cut and worked around obstacles without losing any of these advantages.*

A positive non-slip surface is assured by the traverse members being just proud of the longitudinal members and the right angle construction thus formed makes dirt collection impossible. *Over 100,000 square feet of "OVALOCK" flooring has already been installed at the Portishead Generating Station.*

The fully qualified drawing office staff at Gardiner of Bristol will be pleased to answer any questions on design and installation—prompt attention is assured and full details will be sent on request.

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H-W.118

25 kW continuous output

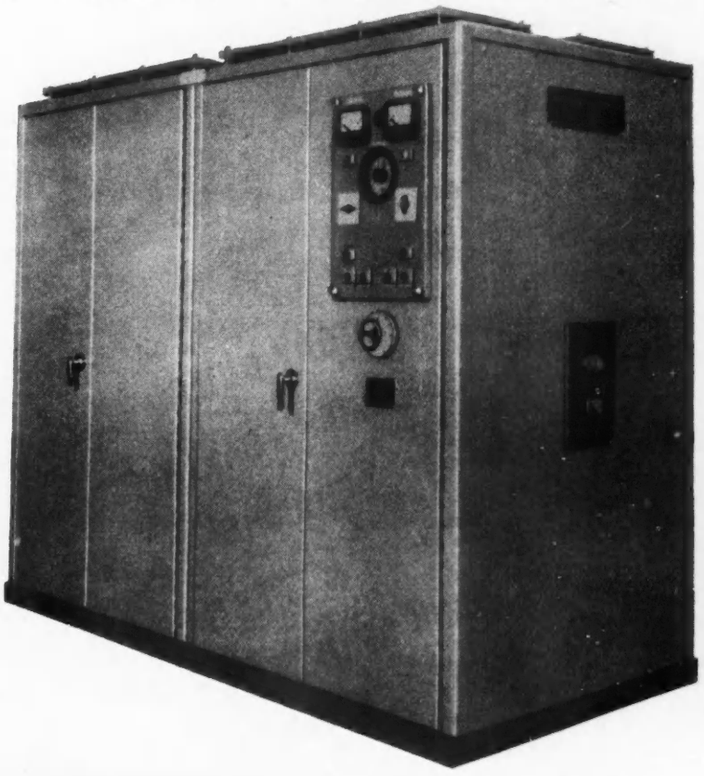
with the

GENERAL PURPOSE INDUCTION HEATER

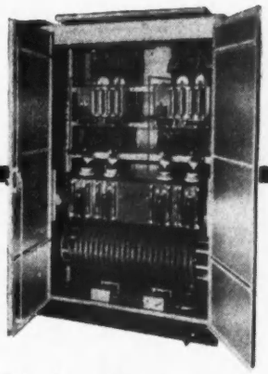
In numerous industrial processes, induction heating provides results that would otherwise be impracticable or unobtainable—particularly where heat-effect must be strictly localised and rigidly controlled.

The new BTH high-frequency generator has been designed for the widest possible range of industrial applications. It is quick and economical in operation—there is no waste heat, and the effect of heat on other parts of the work is minimised. Clean, cool, and fumeless in operation, it readily lends itself to fully automatic operation in a production line.

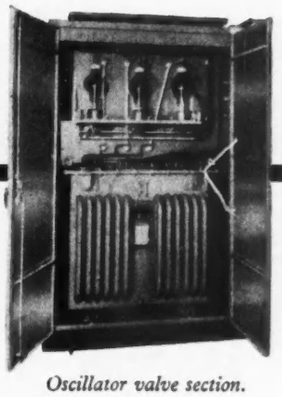
Write for booklet DL5857-3



Type FA27A general-purpose high-frequency generator. Continuous rating: 25 kW. Peak intermittent (50% duty cycle): 30 kW. Output frequency: 400 k/cs. Supply: 3 phase, 50/60 cycles, 380/440 volt.



High voltage thyratron rectifier and transformer section.



Oscillator valve section.

See this new equipment working at
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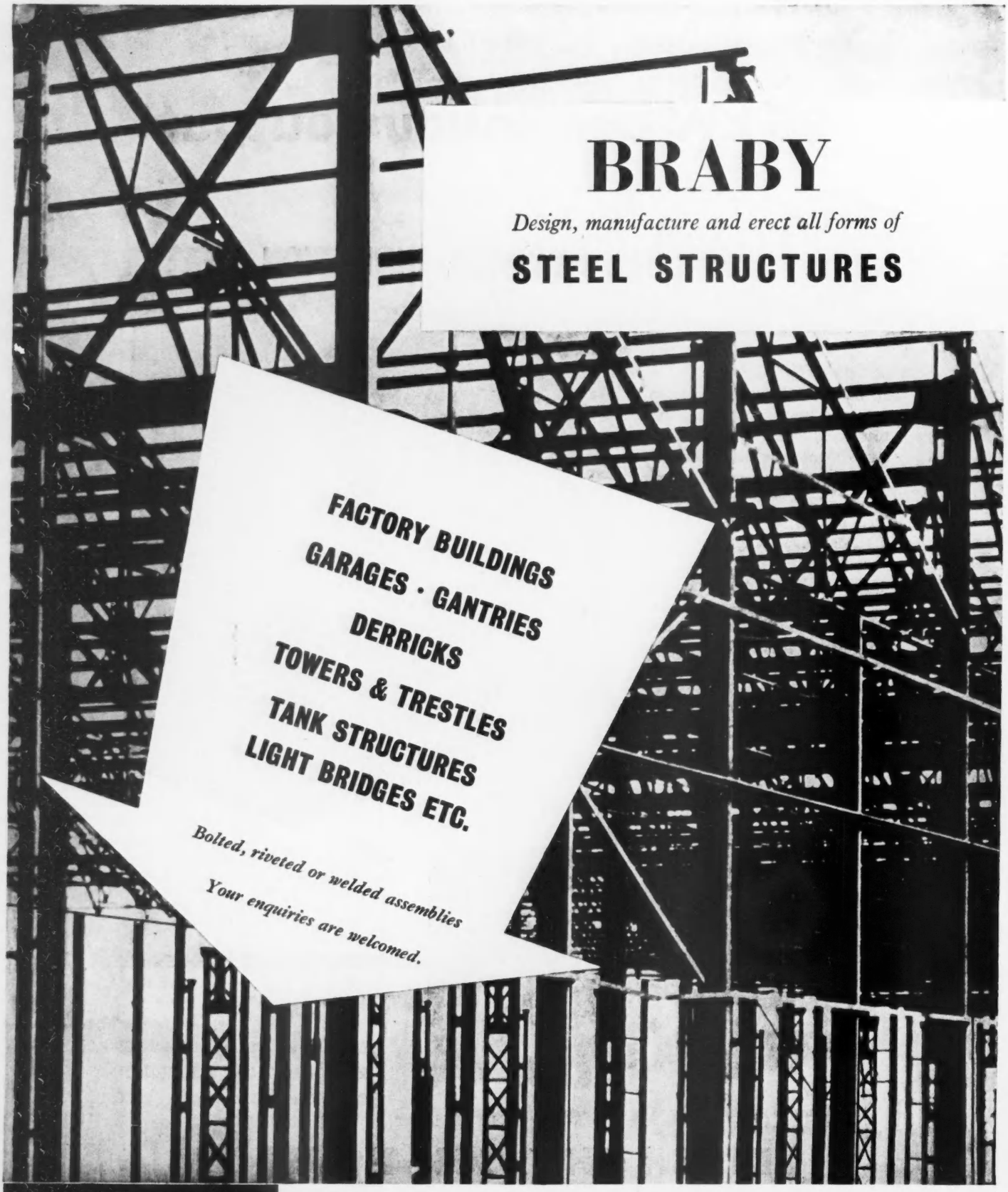

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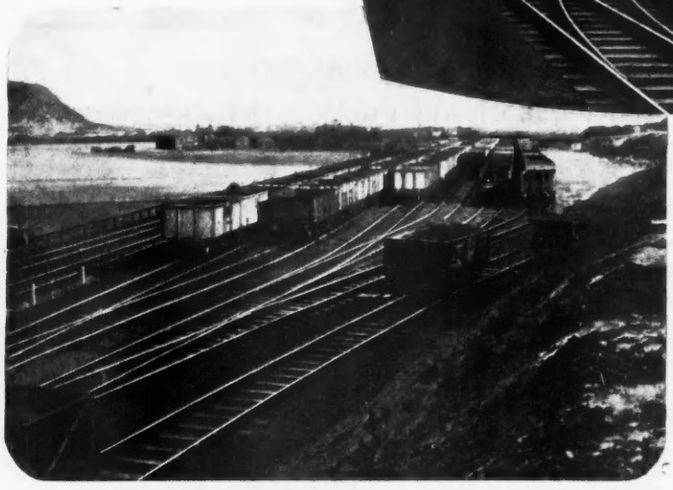
AP285

SIDINGS BY WARDS AT BOLD COLLIERY



Photographs of a recently completed contract at Bold Colliery, St. Helens, S. Lancs, reproduced by permission of the National Coal Board.

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Wards have been building sidings for over sixty years. To-day, Rail Department's large staff of skilled and experienced workers, backed by the resources of the Company, carries out contracts of any magnitude simultaneously.

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We believe that, where no trained combustion staff is available, this Service is almost indispensable."

Eric V. Bowater

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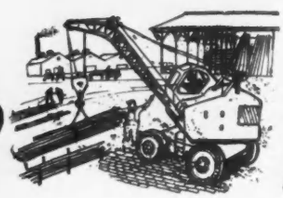

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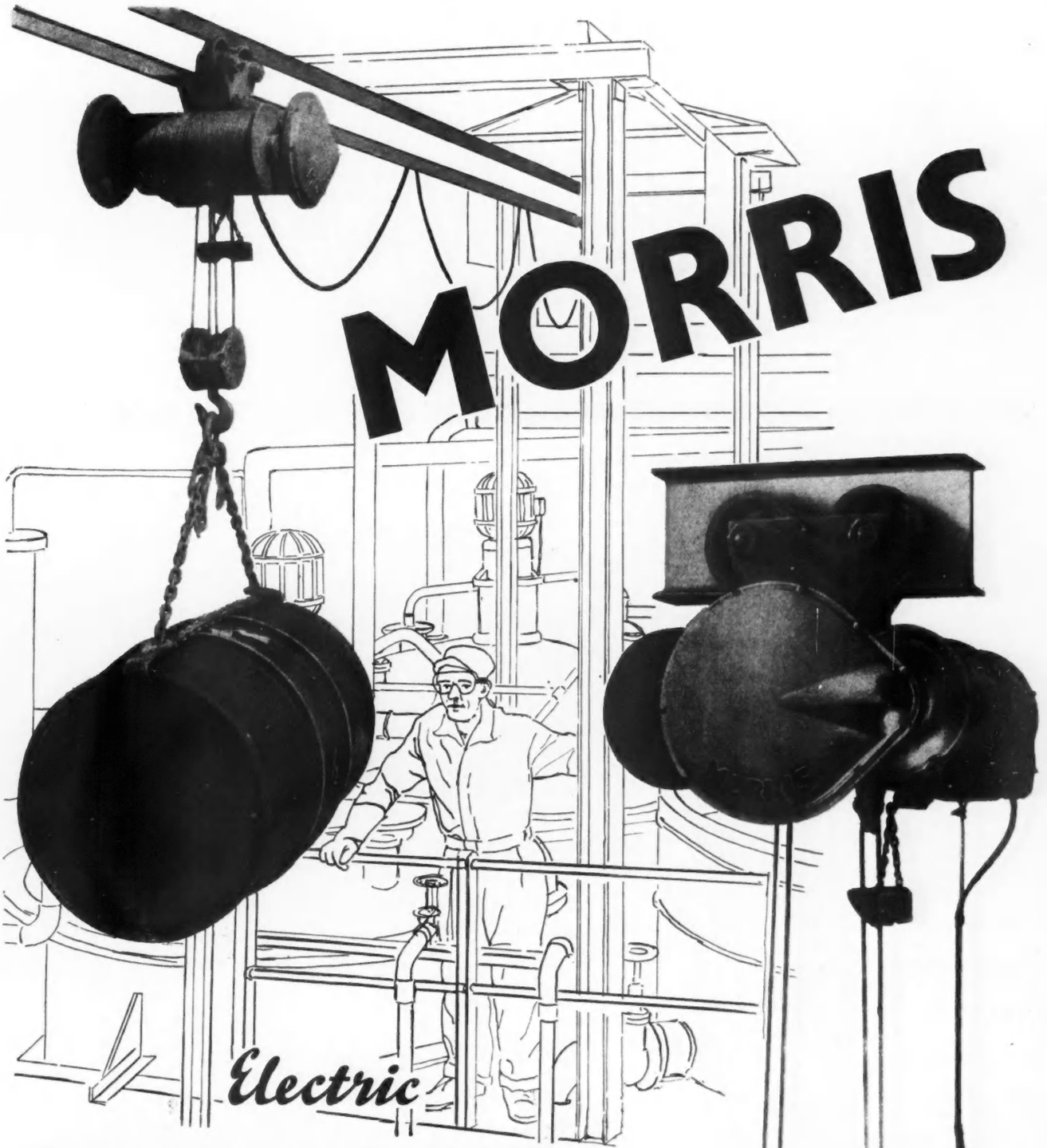

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for LIFTING and MOVING

For many industrial lifting and moving jobs, Morris electric hoist-blocks (in one or other of the types listed below) fulfil requirements successfully and economically. Consider the comprehensive and adaptable Morris range. Push travel (as illustrated). Geared travel (moved by pulling on an endless hand-chain). Flexible bogie types (push or geared travel) for runways with curves. Electric travelling types for either straight or curved runways. Dual speed models with alternative lifting and lowering speeds in addition to normal speeds in one unit adaptable to the same form of suspension and travelling detailed above. **Sizes ¼, ½, 1, 2, 3, 5, 7½ and 10 tons.**

Twenty page Section 73 gives more details.

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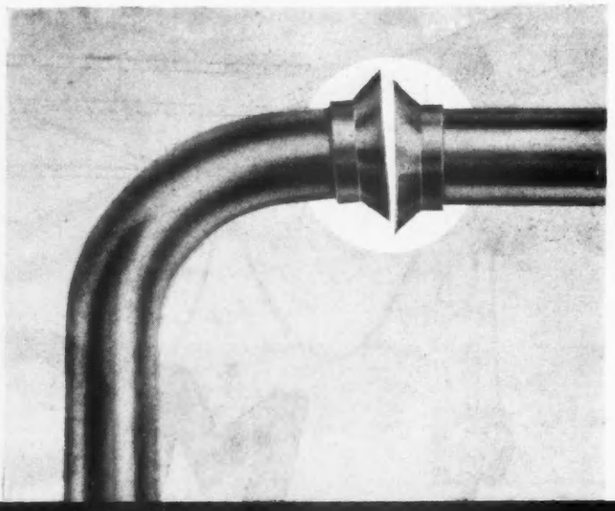
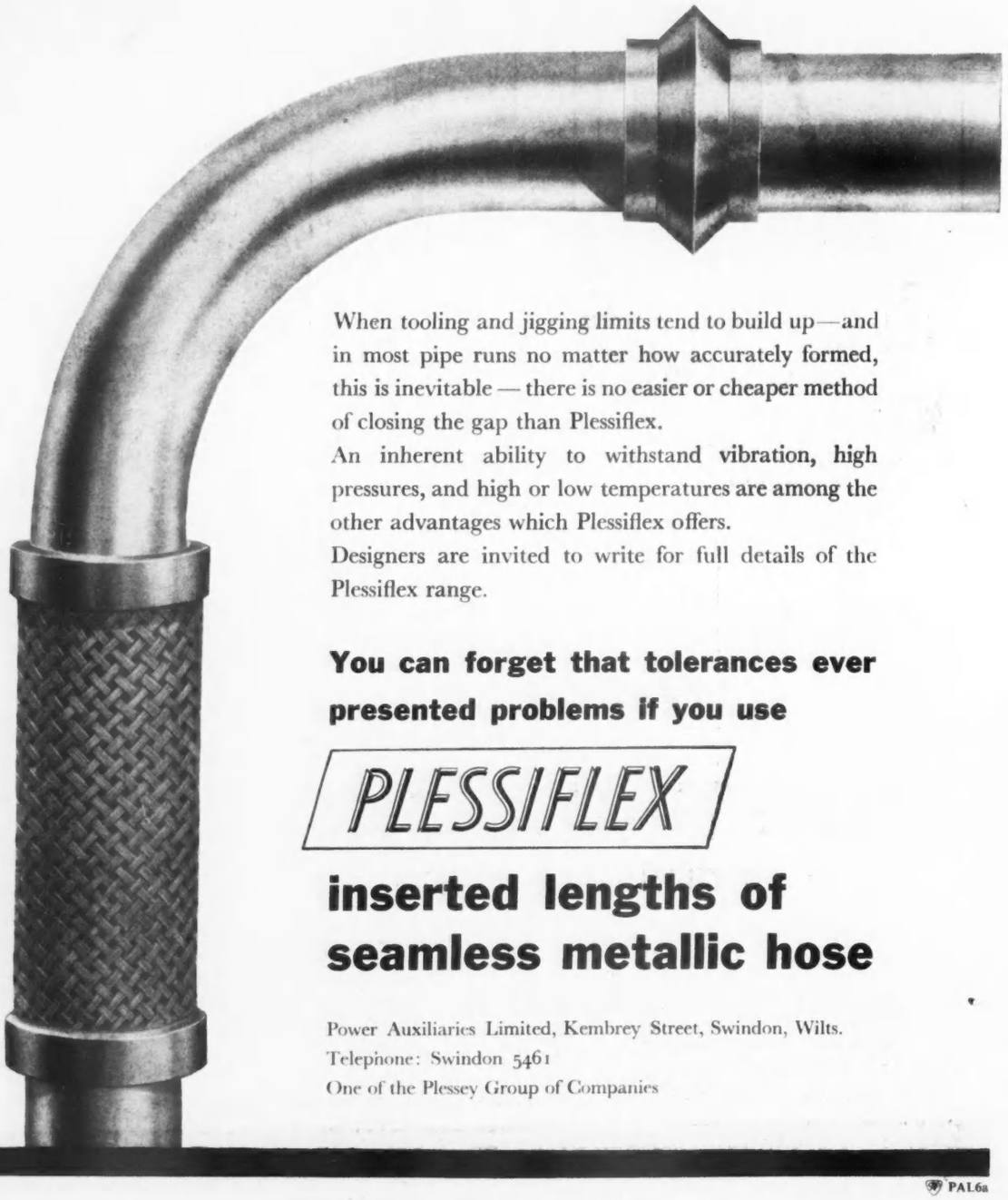
A question of tolerances?





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An inherent ability to withstand vibration, high pressures, and high or low temperatures are among the other advantages which Plessiflex offers.

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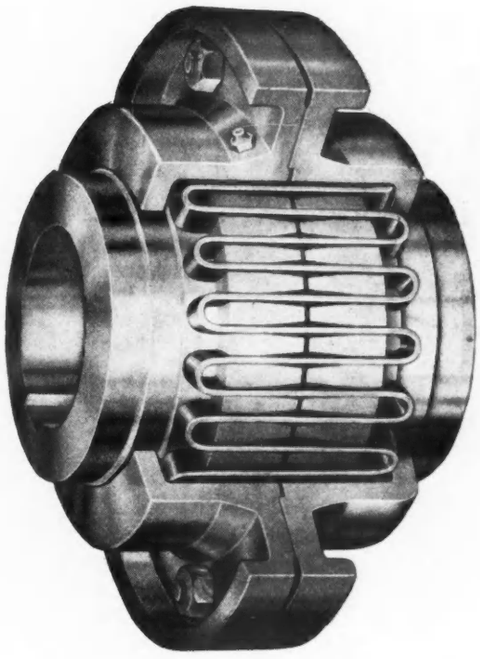

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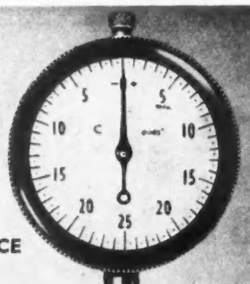

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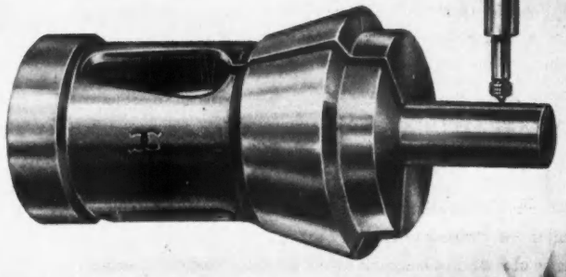

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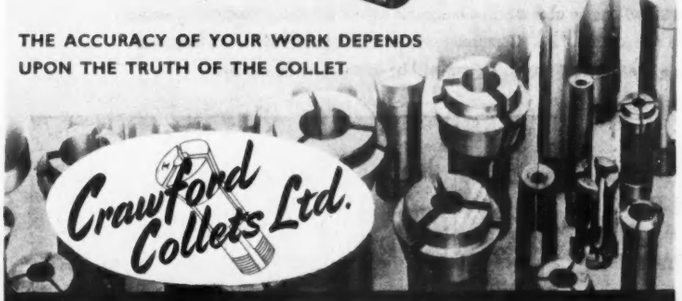

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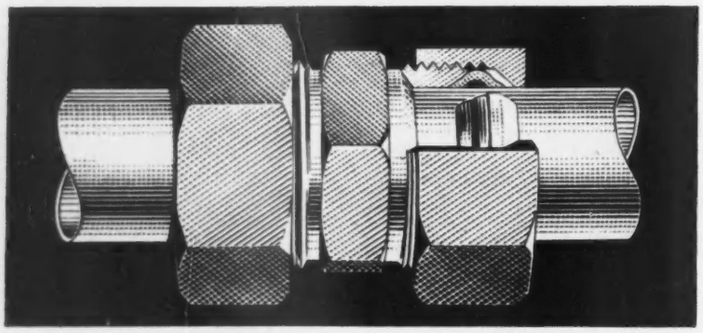
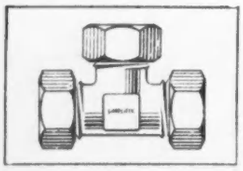
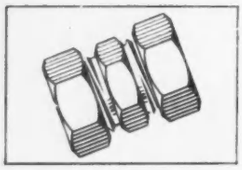
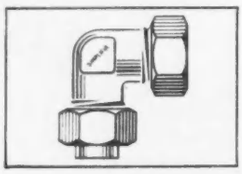
SIMPLIFIX

compression joints









for the perfect compression joint in minutes . . .

Simplifix takes all the bother out of pipe line assembly. Makes safe, leak-proof joints in a matter of seconds. No work to be done on the pipe ends beyond removing the burrs. No distortion to the piping because a special anti-friction washer prevents the pipe from twisting whilst the nut is being tightened.

● *Note: Simplifix fittings can be used on very thin walled tubing.* A full range of fittings, elbows, tees, crosses etc., is available and illustrated in our catalogue which will be sent on request.

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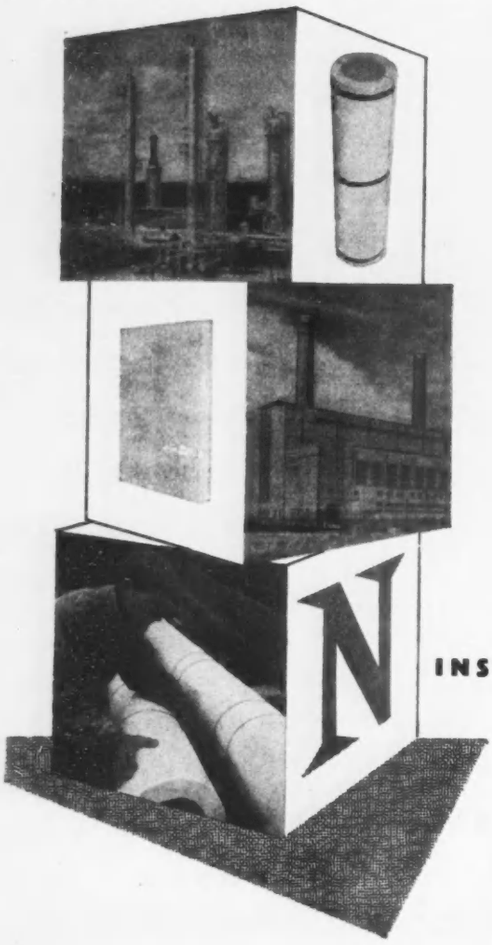

a reputation built on industrial achievement

IF you look through a list of insulation contracts completed in recent years by Newalls you will see that they relate to many of the most important industrial enterprises undertaken since the war. In such a list will appear power stations, oil refineries, chemical works, cold stores, as well as many other plants where effective thermal insulation has been put to profitable use. Nor are our products confined to this country. For example, some 600 tons of thermal insulation material was supplied by Newalls to the British Petroleum Company's refinery at Aden.

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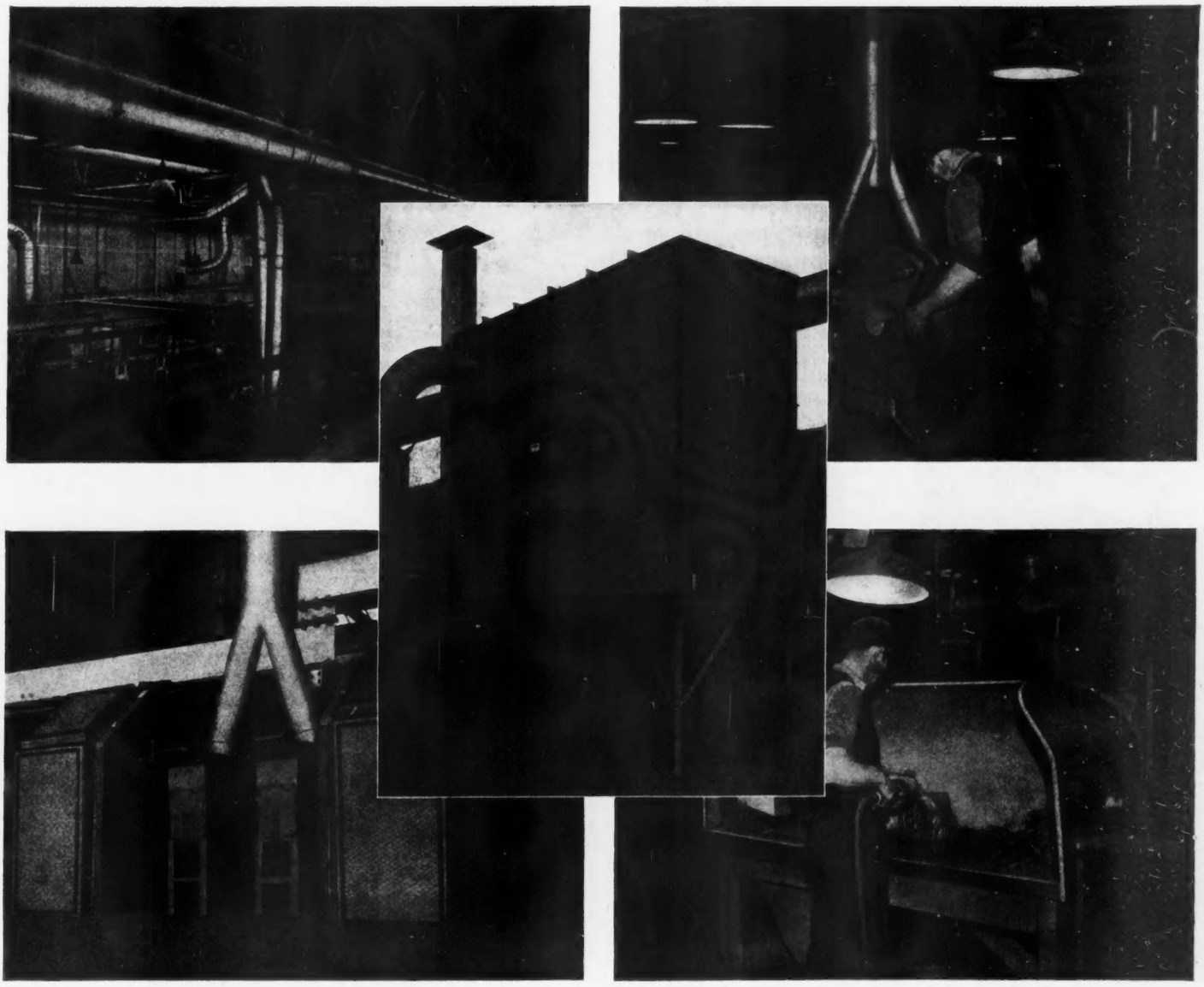

The new Tilghman's Model 126 KD Dust Collector recently installed by Messrs. R. A. Lister & Co., Ltd., of Dursley, occupies 50% less floor space than previous designs of a similar capacity.

This collector was installed to obtain the highest efficiency possible when handling the dust-laden exhaust from rumblers, fettling benches, grinders, shot blast equipment, etc.

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DUST AND FUME CONTROL DIVISION

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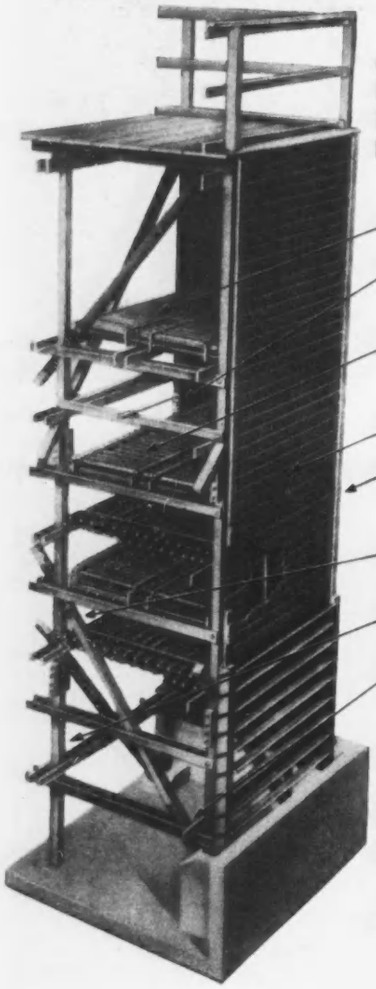
N.135

FW timber induced-draught cooling-tower



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3. Double diamond fill racks of 1" square timber affording rigidity and long life.
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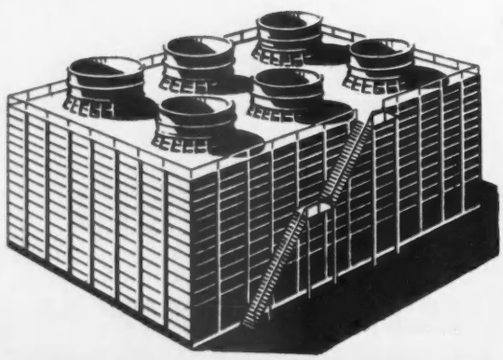

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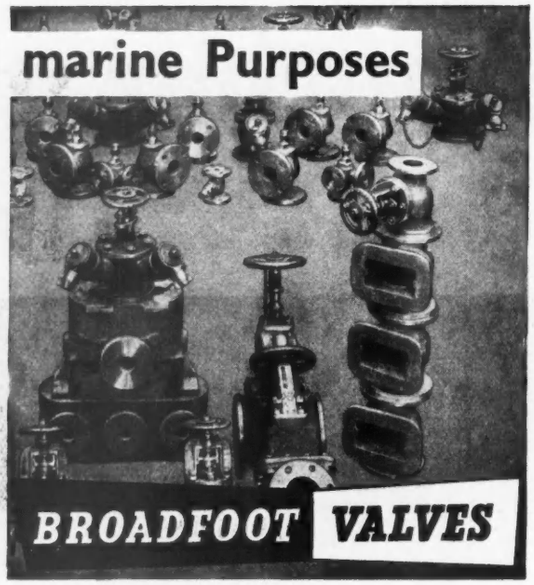

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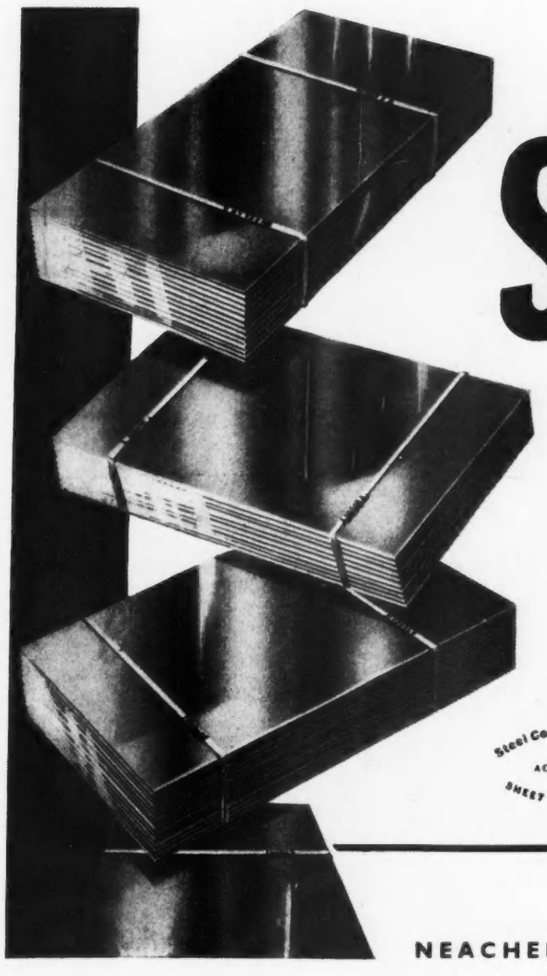

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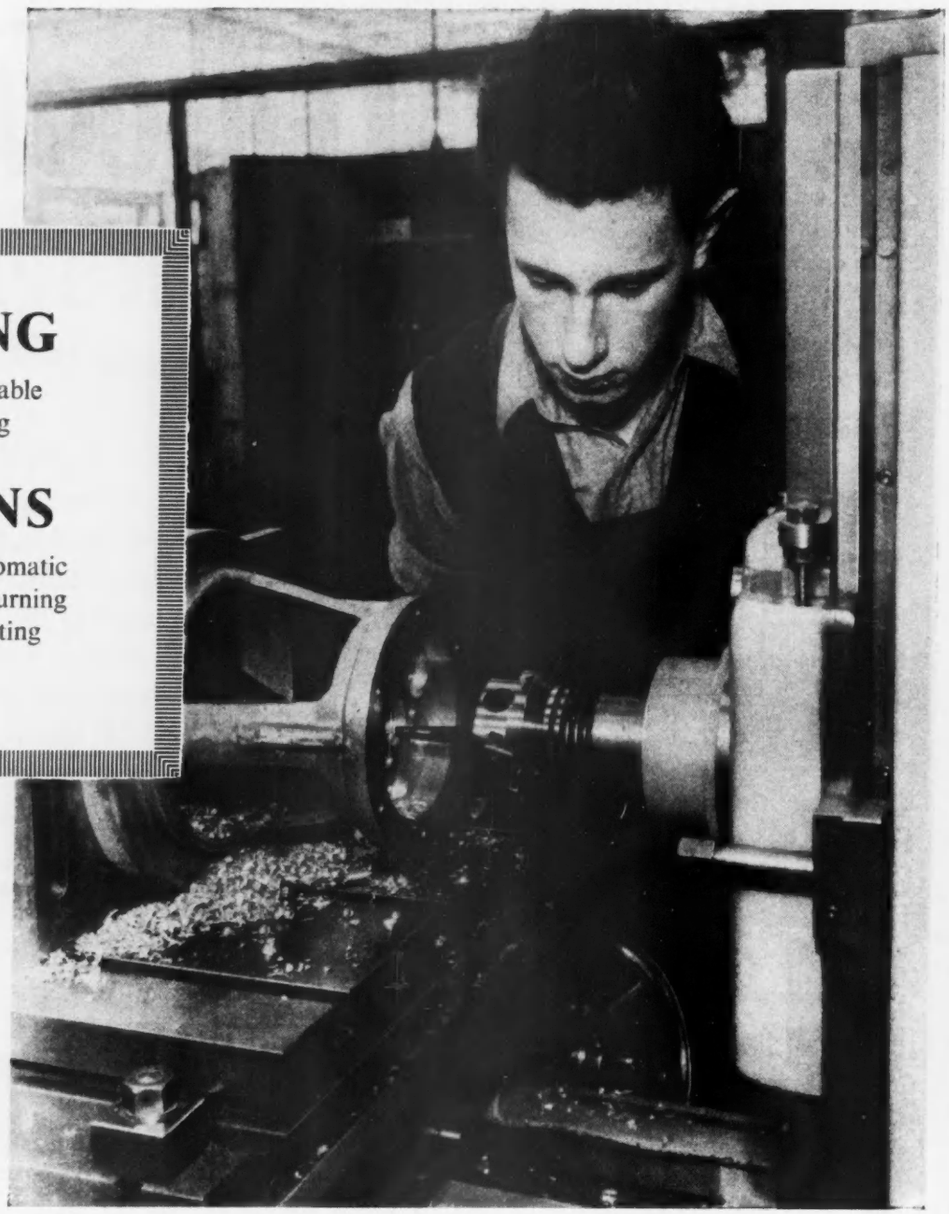

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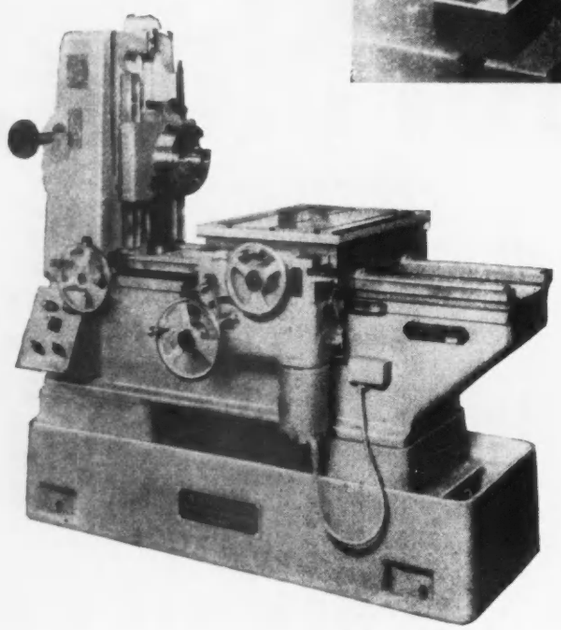

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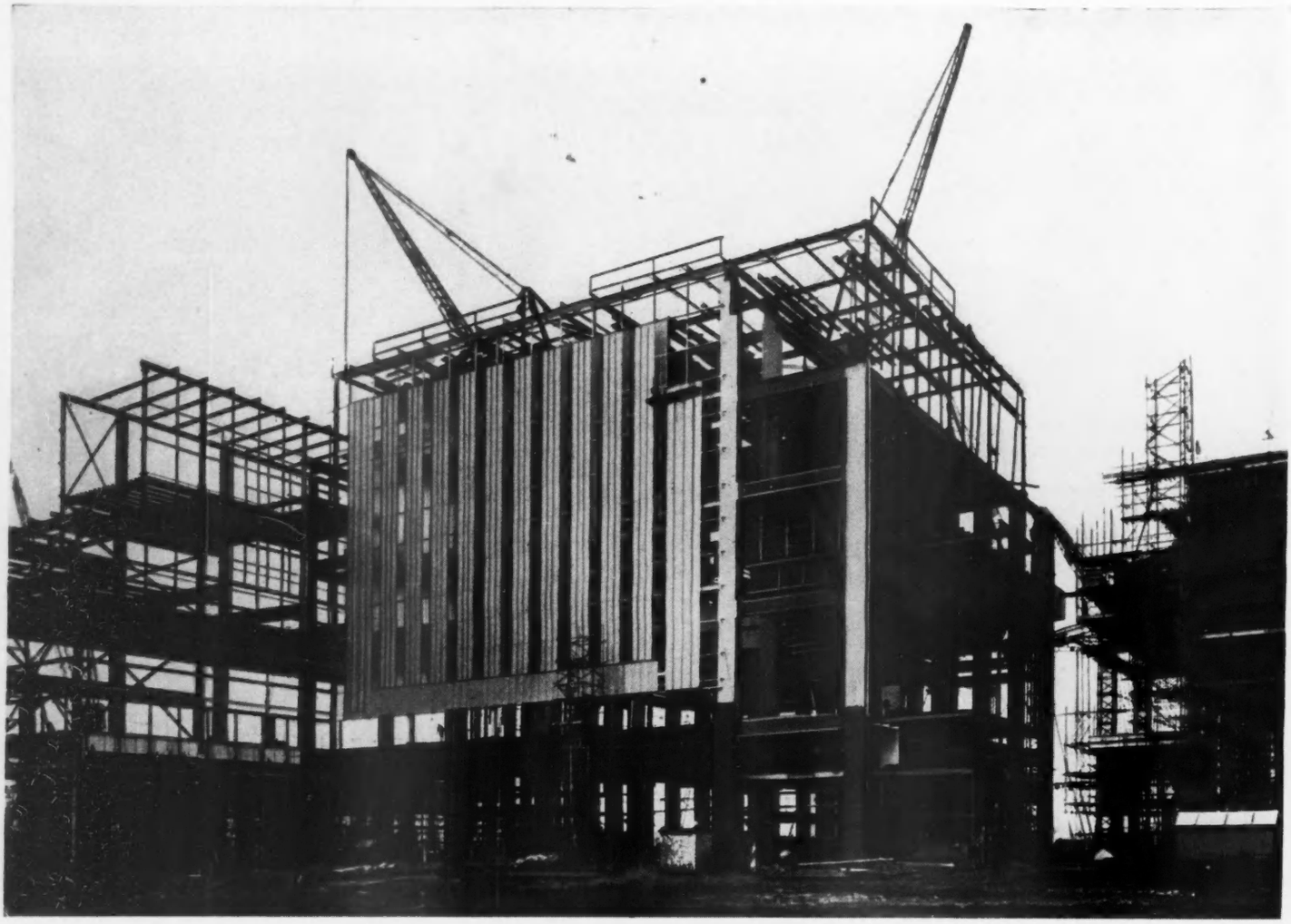

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work advanced on first of five 200 MW units

Construction work is now well under way at High Marnham on the first of the five reheat boiler units which IC are supplying to the CEGB. These five controlled circulation units will be pulverised fuel fired and operate under advanced conditions of temperature and pressure.

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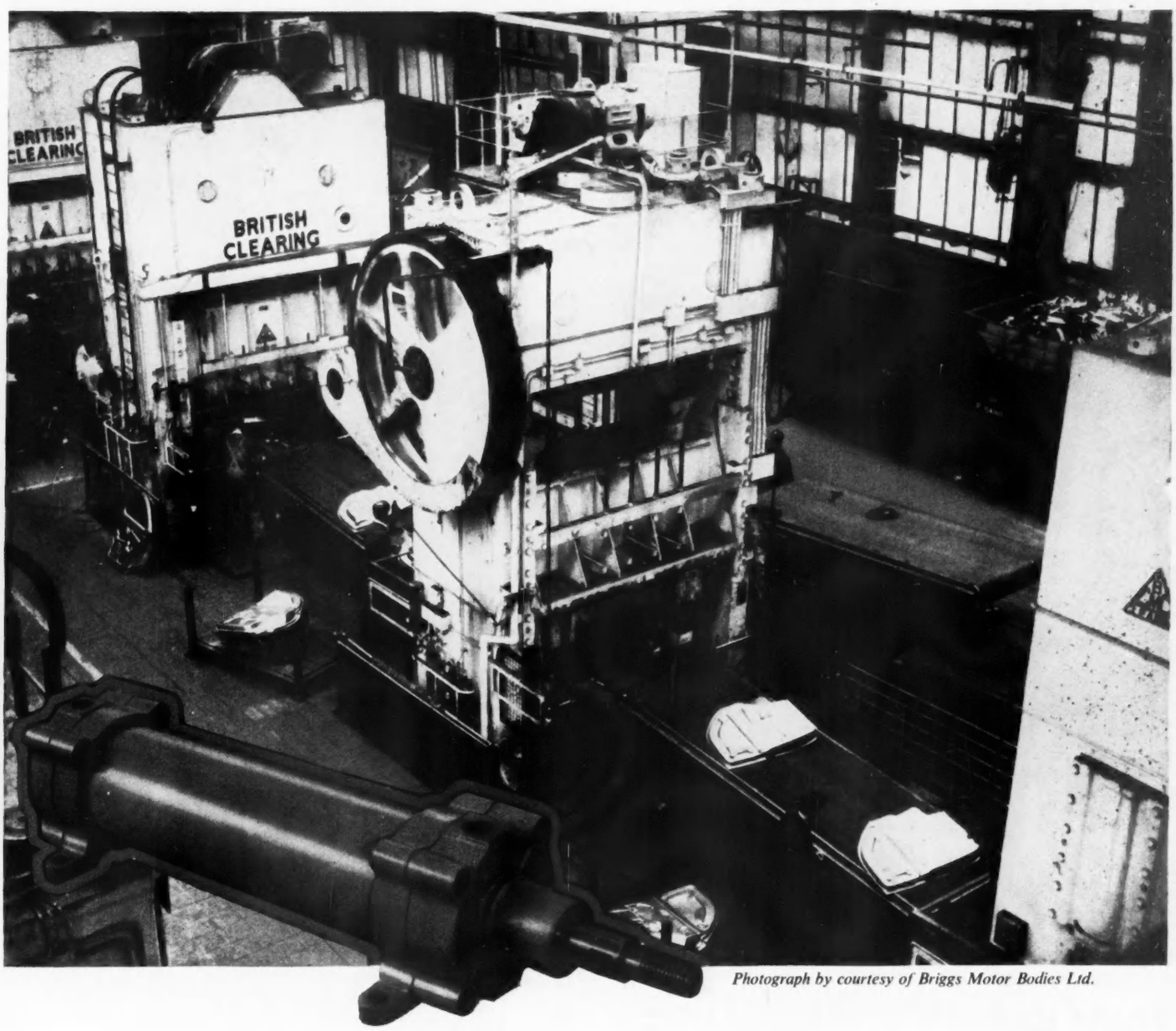

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The air cylinders supplied by Baldwin Instrument Co. Ltd., to provide power operation for automatic work handling devices, have 'Fescol'-ised bores and piston rods to reduce friction and ensure maximum life from seals. This is one further example of the way in which Fescol, who pioneered the electro-deposition of nickel and chrome for engineering purposes, still lead the way, adapting their process to help each new industrial development.

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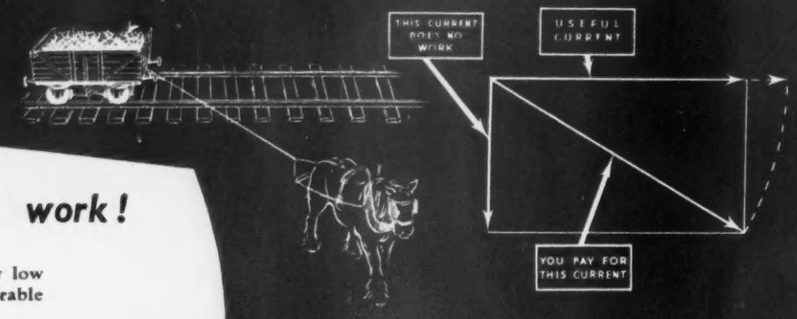

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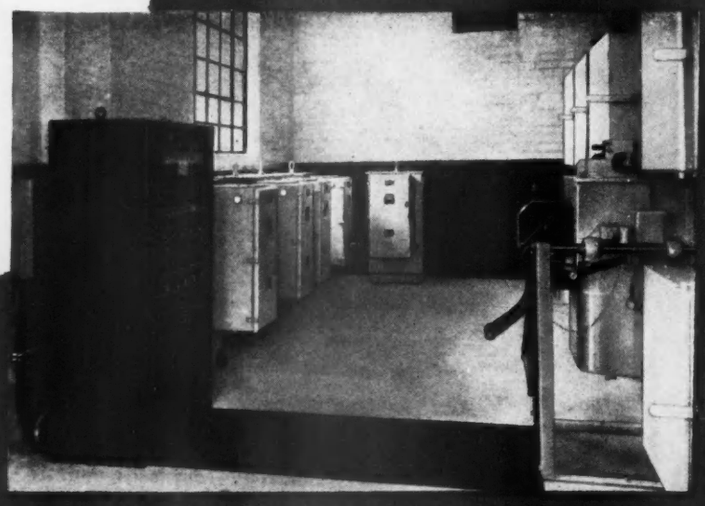

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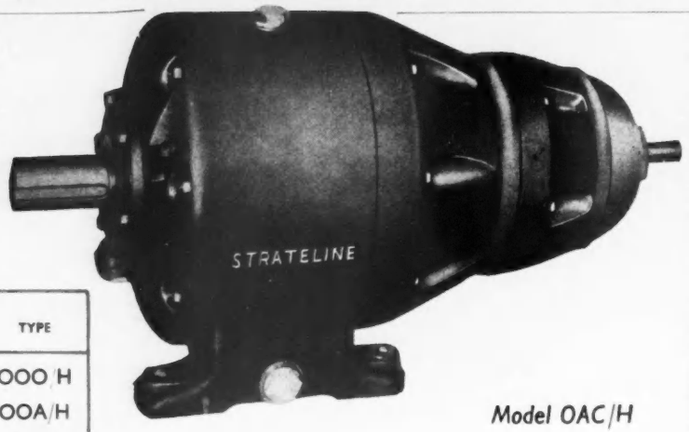

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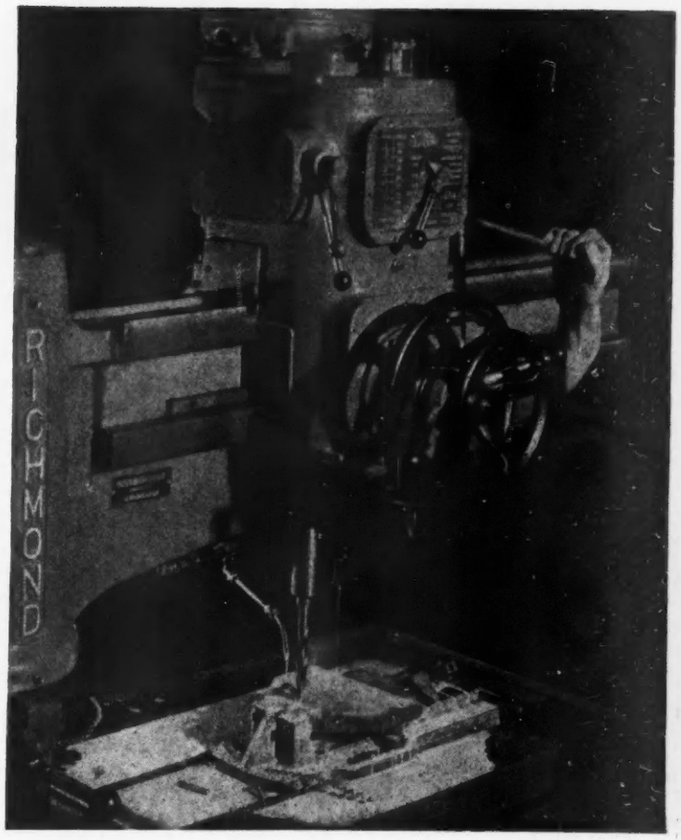

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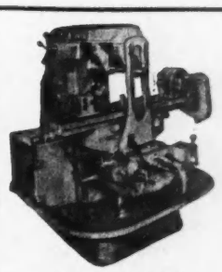

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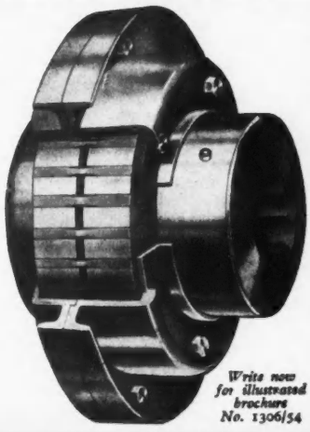

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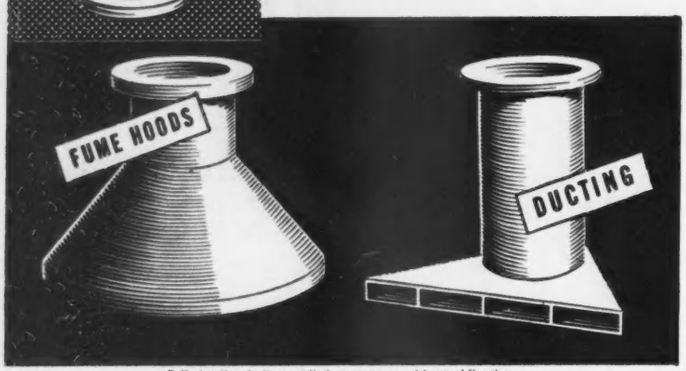

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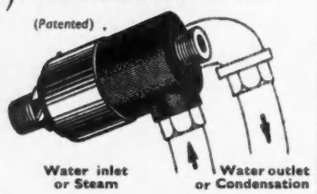

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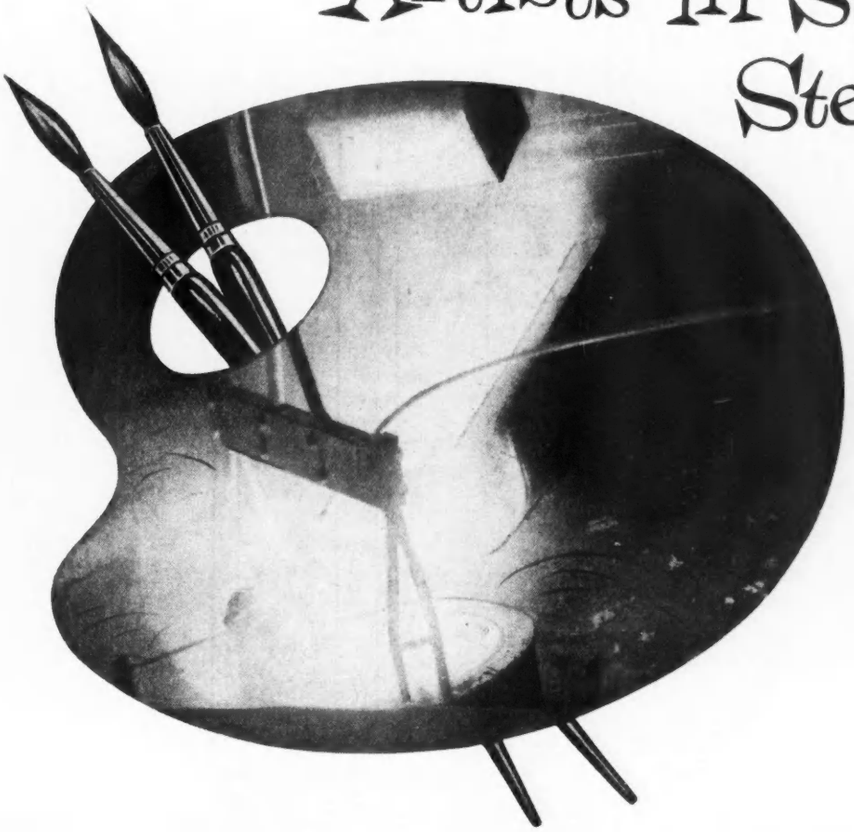

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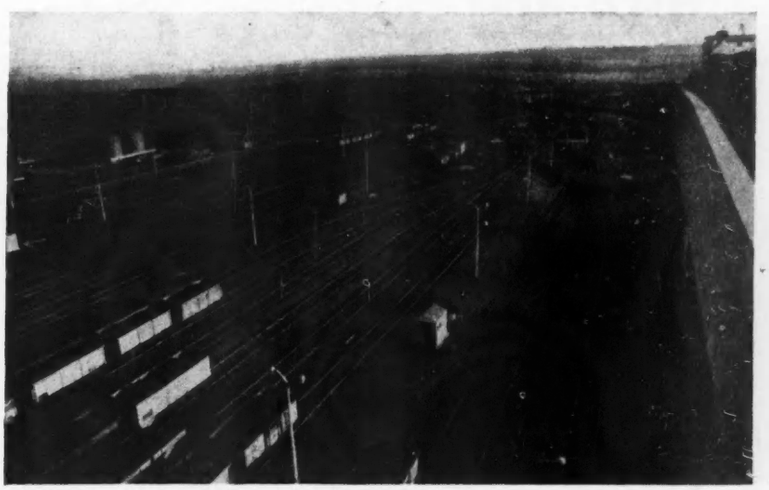
MANVERS CENTRALIZATION SCHEME :

From the top of the newly constructed Coal preparation plant a small section of the immense network of railway sidings

The supply and installation of these sidings and the adjoining trackwork for the new Coal Carbonization and Benzole Rectification Schemes were entrusted to the Eagre Construction Co., Ltd., by the National Coal Board. Over 9,000 tons of Iron and Steel were used in the construction of the forty miles of track and 230 turnouts and Special Point and Crossing layouts comprising the combined railway Sidings.

Eagre's skilful planning and practical experience in the day-to-day working of Colliery Sidings ensured that this vast scheme was laid efficiently to schedule, and without the slightest interruption of existing Colliery traffic.



Photograph by courtesy of National Coal Board

WORK BEGINS AT CADEBY :

The National Coal Board again entrusts the Eagre Construction Co. Ltd. with a similar project. Earthworks, Drainage, Track Laying and ancillary works for thirteen miles of Sidings are now in progress at Cadeby Main.

for a complete Track Service

Photograph by courtesy of National Coal Board

In addition to its activities in the Nation's Coalfields, the Eagre Construction Co. Ltd. has worked continuously during the past ten years for British Railways, the Gas Board, the United Steel Companies, and has carried out large Power Station Projects for the Central Electricity Authority.

SURVEY
DESIGN
SUPPLY
INSTALLATION

Whatever the magnitude of your siding requirements, be sure to consult

EAGRE CONSTRUCTION CO. LTD.
East Common Lane SCUNTHORPE Lincs.

EAGRE

Telephone: Scunthorpe 4513-7

WHEN YOU DEPEND UPON

wire and wirecloth . . .

"UNITED'S" long experience of the precision and control essential to high quality manufacture of wirecloth and non-ferrous wire enables them to give an unrivalled specialist service to a multiplicity of industries. They can provide immediate delivery from stock of normal meshes and standard metals — or weave wirecloth to your own specification from 1-400 mesh.

THE UNITED WIRE WORKS LTD

GRANTON · EDINBURGH · 5 · SCOTLAND

Telegrams & Cables: SCOTIA, EDINBURGH, TELEX Telephone: GRANTON 83245 (8 lines)

SAFER with . . .
Siebe, Gorman

IN MANUFACTURING INDUSTRY, mining, rescue work, firefighting, deep-sea diving and similar occupational hazards everywhere, Siebe, Gorman equipment is safeguarding life and health.
Here are some typical applications :

BREATHING APPARATUS. Self-contained Compressed Air types, Marks II and III and Oxygen types, 'Proto,' 'Salvus,' 'Lungovox' and 'Fireox.'

RESPIRATORS. The range includes the Compressed Air Line Respirator (illustrated) and the 'Puretha' Mark IV Gas Respirator.

RESUSCITATION APPARATUS. Oxygen types for asphyxia, electric shock, etc., including the 'Novox' and 'Novita.'

PROTECTIVE CLOTHING of every description including helmets, goggles, dust and fume respirators.

Established 1819

SIEBE, GORMAN & CO. LTD. LONDON — EVERYTHING FOR SAFETY EVERYWHERE

NEPTUNE WORKS, DAVIS RD., CHESSINGTON, SURREY

Telegrams : Siebe, Chessington. *Telephone : Elmbridge 5900*

S.G.T.

"SYKES"

PORTABLE SELF-PRIMING CENTRIFUGAL PUMPS
DIRECT COUPLED TO PETROL & DIESEL ENGINES

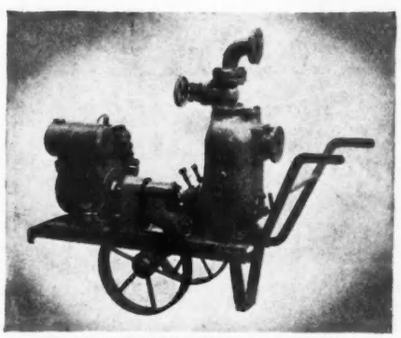


Fig. 245. S.P.B.2 Mk.III. Portable petrol driven self-priming centrifugal pumps.

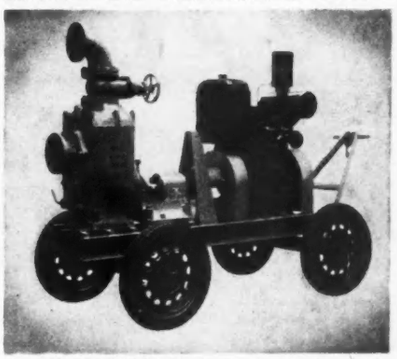


Fig. 281. S.P.B.6 Mk.III. Portable Diesel engine driven self-priming centrifugal pump.

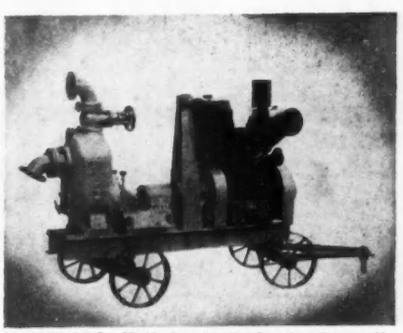


Fig. 247. S.P.C.4 Mk.III. Portable diesel engine driven self-priming centrifugal pump.

These robust Pumps have been designed for the onerous conditions met with on Civil Engineering Contracts and for similar duties. Self priming is by the re-circulation method and there are no complicated or delicate parts; the gunmetal impeller is of the open type specially designed to minimise clogging and the volute is fitted with a renewable steel rubbing plate.
The flanged suction and delivery openings are drilled to suit B.S. Table "D".
Capacities range up to 90,000 gallons per hour against heads up to 100 ft.

Quotations will be sent on request for any portable, temporary or emergency pumping set likely to be required by Civil Engineering Contractors, Builders, Local Authorities, Quarry & Pit Owners, Canal Companies, Railways, Water & Gas Undertakings, Farmers, Government Departments and others.
Pumps can be supplied Electrically Driven, when making an enquiry give details of electrical supply available.

Complete Outfits or Separate Components available for HIRE or SALE

HENRY SYKES LTD., SOUTHWARK ST., LONDON, S.E.1

Telephone: HOP 5231 (8 lines) Branch Exchange. Telegraph: TRIPULSE, SEDIST, LONDON

Australian Enquiries to: Motor Tractors Pty., 369-385 Wattle Street, Ultimo, N.S.W.

Floccinaucinihilipilification!

Longest English word? We wouldn't know! But it's in the Oxford Dictionary all right. Means "*the action or habit of estimating as worthless*"—which isn't one of our habits. Nor is it our habit to use words, or anything else, which 'drag their slow length along'. That would be quite contrary to our Scrap Trading policy. We're all for action and getting a move on. What's more, we always buy on absolutely fair terms. Which is one of the reasons why we've lasted for over 120 years, and are still growing.

SCRAP *for* COHEN'S
COHEN'S *for* SCRAP

THE 600 GROUP OF COMPANIES

GEORGE COHEN SONS & COMPANY LIMITED
RAW MATERIALS DIVISION

Experts in Scrap since 1834

WOOD LANE, LONDON, W.12 · *Telephone:* Shepherd's Bush 2070 · *Telegrams:* Coborn, Telex, London · And at 600 Commercial Road, E.14 Canning Town, E.16 · Southall, Middx. · Bath · Belfast · Kingsbury · Hebburn · Leeds · Luton · Manchester · Sheffield · Swansea Southampton · Glasgow

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, *e.g.*, ½-page £25 10s. ¼-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, *e.g.*, ½-page £22. ¼-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/-, which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*— Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

COLLEGE OF TECHNOLOGY

BIRMINGHAM

(DESIGNATED COLLEGE OF ADVANCED TECHNOLOGY)

LECTURERS

Applications are invited for the following posts : SENIOR LECTURERS and LECTURER IN MECHANICAL ENGINEERING (specialising in either Strength of Materials, Mechanics of Fluids, Thermodynamics, Mechanics of Machines or Machine Design.

SENIOR LECTURER IN PRODUCTION ENGINEERING (preferably Forming or Welding).

LECTURER IN PRODUCTION ENGINEERING.

Salary : Senior Lecturers (men) : £1350 by £50 to £1550 ; Lecturers (men) : £1200 by £30 to £1350.

In fixing the commencing salary, account may be taken of industrial, professional or research experience up to the maximum of the scale.

Further particulars and forms of application from the Registrar, College of Technology, Suffolk Street, Birmingham, 1, on receipt of stamped, addressed foolscap envelope. Applications to be received within 14 days of this advertisement.

K. R. PILLING,
Clerk to the Governing Body.
E6752

COUNTY BOROUGH OF BRIGHTON EDUCATION COMMITTEE

BRIGHTON TECHNICAL COLLEGE

ASSISTANT LECTURER

Required for 1st September :

ASSISTANT LECTURER (Grade B) IN MECHANICAL and/or PRODUCTION ENGINEERING. Graduate A.M.I.Mech.E., or A.M.I.Prod.E. Teaching experience is desirable.

Salary scale : £650 by £25 to £1025 (men), plus Graduate and training allowances and with increments for approved research, professional or industrial experience.

Further particulars and forms of application from the undersigned, to be returned to the Principal, Brighton Technical College, Brighton, 7, by 26th April.

W. G. STONE,
Director of Education.
54, Old Steine, Brighton.
E6692

BEDFORDSHIRE EDUCATION COMMITTEE

THE MANDER COLLEGE

BEDFORD

LECTURER

Applications are invited for appointment as LECTURER IN MECHANICAL ENGINEERING as from 1st September, 1958. Candidates should be Graduates with industrial experience, qualified to teach Applied Thermodynamics and Fluid Mechanics to H.N.C. standard.

Salary scale : £1200 by £30 to £1350. Increments may be added, up to the maximum, for approved industrial experience.

Forms of application and further particulars obtainable from the College Principal.

T. S. LUCKING,
Director of Education.
E6787

THE UNIVERSITY OF SHEFFIELD

LECTURER

Applications are invited for a post of LECTURER IN CIVIL ENGINEERING, to begin duties on 1st October, 1958, or as soon as possible thereafter. Salary scale : £900 by £50 to £1350 by £75 to £1650, with F.S.S.U. provision and family allowance. Initial salary according to qualifications and experience.

Further particulars may be obtained from the Registrar, to whom applications (4 copies) should be sent by 28th April, 1958.
E6749

PUBLIC APPOINTMENTS

ROYAL CORPS OF NAVAL CONSTRUCTORS

SCHOOLS ENTRY

A COMPETITION FOR ENTRY INTO THE ROYAL CORPS OF NAVAL CONSTRUCTORS will be held in July, 1958.

Accepted candidates will be established as Probationers in the R.C.N.C. and will undergo a 2-year course of training at the R.N. Engineering College, Manadon, and in H.M. Dockyard, Devonport, followed by a 3-year course at the R.N. College, Greenwich.

Candidates must be aged between 18 years and 19 years 6 months, inclusive, on 1st September, 1958.

Candidates with the General Certificate of Education will be required to have passed at Advanced Level in at least Pure Mathematics, Applied Mathematics and Physics, and to produce evidence of general education at Ordinary level.

Candidates with the Scottish Leaving Certificate will be required to have higher grade passes in Physics and Mathematics and at least lower grade passes in English and a language other than English and two other subjects (preferably mathematical).

Candidates from schools in Northern Ireland will be required to produce a certificate from the Ministry of Education in Northern Ireland, showing a comparable standard to that above.

The work of the R.C.N.C. covers all aspects of design construction and repair of H.M. Ships. Members undertake to serve wherever required at Admiralty Headquarters and outports in the United Kingdom, and at Royal Dockyards at Home and Abroad. The Head of the R.C.N.C. is the Principal Technical Adviser to the Board of Admiralty.

The starting pay of a Probationer at age 18 will be £535. A deduction of £75 is made when living in at the R.N. Engineering College, Manadon, or at the R.N. College, Greenwich. The successful Probationer can expect appointment as Assistant Constructor at age 23 or 24, with a starting salary in London of not less than £905 and £935, respectively Promotion to Constructor normally takes place at about age 30, with a salary which may be expected to be not less than £1435, rising in nine years to not less than £2050. Promotion to higher ranks is by selection.

Full particulars may be obtained from the Secretary of the Admiralty, C.E. Branch II, Empire Hotel, Bath, to whom final application must be submitted by 16th June, 1958.
E6608

THE UNIVERSITY OF LIVERPOOL

DEPARTMENT OF MECHANICAL ENGINEERING

LECTURER

Applications are invited for the post of ASSISTANT LECTURER or LECTURER in the Department of Mechanical Engineering. The salary range for an Assistant Lecturer is £700–£850 per annum ; the initial salary for a Lecturer will be within the range £900–£1650 per annum, according to qualifications and experience.

Applications, stating age, academic qualifications and experience, together with the names of three referees, should be received not later than 26th April, 1958, by the Registrar, from whom further particulars of the conditions of appointment may be obtained.
E6673

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE

SENIOR LECTURER

Applications are invited for a post as SENIOR LECTURER IN MECHANICAL ENGINEERING. Duties will commence on a date to be arranged.

Candidates should hold a good Honours Degree in Mechanical Engineering and have practical experience in industry, teaching and/or research. Salary in accordance with the Burnham Technical Scale for Senior Lecturers (£1350 by £50 to £1550 per annum).

Further particulars and application form will be sent by the undersigned. Applications should reach the undersigned not later than Monday, 28th April, 1958.

E. C. SMITH,
Principal.
March, 1958.
E6773

PUBLIC APPOINTMENTS

AIR MINISTRY WORKS DESIGN BRANCH

LONDON

DESIGNER DRAUGHTSMEN

Air Ministry Works Design Branch require in London DESIGNER DRAUGHTSMEN for Bulk Petroleum Storage and Pumping Installations, experienced in one or more of the following : (a) storage tank layout and design ; (b) pump house and plant layout ; (c) development of pipe line schemes ; (d) hydraulic calculations. Technical training to O.N.C. standard required.

Salaries up to £1015 per annum. Starting pay dependent on age, qualifications and experience. Long term possibilities with pensionable and promotion prospects. 5-day week, 3 weeks' 3 days' leave a year. Normally natural born British subjects.

Write, stating age, qualifications, employment details, including type of work done, to any Employment Exchange, quoting Order No. Borough 105.
E5049

ATOMIC ENERGY RESEARCH ESTABLISHMENT

HARWELL

TECHNICIAN

Atomic Energy Research Establishment, Harwell, requires an apprenticed or similarly trained TECHNICIAN to place and progress contracts for prototype and experimental engineering equipment. This involves technical planning, cost estimates and technical liaison. Experience of contract and manufacturing problems desirable.

Salary : £875 (at 30) to £1050.

Housing, superannuation and excellent conditions.

Send postcard to Recruitment Officer (1081/25), A.E.R.E., Harwell, Didcot, Berks, for application form and details.
E6751

DURHAM COUNTY WATER BOARD

APPOINTMENTS

Appointment of ENGINEERING ASSISTANT. "Special Scale" (£750 to £1030 per annum). (Must be Corporate Member, Inst. Mech.E.)

Appointment of GENERAL PLANT FOREMAN. Miscellaneous Grade VI (£645 to £725 per annum). (Housing available for this post if required.)

Particulars and application forms may be obtained from A. C. Wildsmith, M.I.C.E., M.I.W.E., Chief Engineer, Neville Court, Durham, and completed forms must reach the undersigned not later than noon, Monday, 28th April, 1958.

Canvassing, in any form, will disqualify.

C. GIBSON,
Clerk to the Board.
43, Old Elvet, Durham,
1st April, 1958.
E6763

NORTHERN GAS BOARD

DARLINGTON DIVISION

TECHNICAL ASSISTANT (MECHANICAL)

Applications are invited for the position of TECHNICAL ASSISTANT (MECHANICAL) at the Darlington Unit. Duties include the maintenance of plant, machinery and buildings, and the minimum qualification for the post is a Higher National Certificate in Mechanical Engineering or an equivalent Ministry of Transport qualification. The position offers opportunities to a sea-going engineer, seeking a shore appointment.

Salary grading A.P.T. 7/8 (£705–£825 per annum), initial placing according to qualifications and experience.

The successful candidate will be required to pass a medical examination and to join the Board's pension scheme.

Applications, stating age, qualifications and experience, together with the names of two referees, should be addressed to Mr. Charles Hindle, Sub-Divisional Manager, Northern Gas Board, Gas Offices, John Street, Darlington, to arrive not later than April 30th, 1958.

F. WILSON,
Divisional General Manager.
E6761

PUBLIC APPOINTMENTS

NORTH EAST DERBYSHIRE JOINT WATER COMMITTEE

TECHNICAL STAFF

Applications are invited for the following appointments on the staff of the Engineer and Manager.

The commencing salary will be in accordance with qualifications and experience.

These appointments offer good experience in waterworks design and construction.

SENIOR ASSISTANT ENGINEER (A.P.T. IV, £1025–£1175 per annum).

Applicants must be Corporate Members of the Institution of Civil Engineers and they should have had previous experience in the design and construction of service reservoirs, treatment plants and pumping stations.

ASSISTANT ENGINEER (Special Classes Grade, £750–£1030 per annum).

Applicants should be University Graduates or Graduates of the Institution of Civil Engineers and they should have had at least five years' experience. Experience in reinforced concrete design and construction would be an advantage.

Housing accommodation will be made available to the successful applicants and car allowance will be paid up to 8 H.P. in accordance with the National Scales.

The posts are superannuable and the successful applicants will be required to pass a medical examination.

Applications, stating age, qualifications, experience and appointments held together with the names of two referees, should be submitted to the undersigned not later than Thursday, 8th May, 1958.

H. O. HAWKINS,
Clerk,
Rural Council House, Saltergate, Chesterfield,
29th March, 1958.
E6722

ROYAL NAVAL SCIENTIFIC SERVICE

APPOINTMENTS

Royal Naval Scientific Service requires PHYSICISTS, ELECTRONIC ENGINEERS and MATHEMATICIANS for 25 Senior Scientific and Scientific Officer posts at establishments in London area, Baldock, Harwell, Haslemere, Poole, Greenock and Rosyth. Also required : MECHANICAL ENGINEER for work on heat transfer problems at Harwell ; MECHANICAL ENGINEER for work on fuel and lubricating oil problems in London area ; MECHANICAL ENGINEER for work on gas turbine and problems in London area ; CHEMICAL ENGINEERS for London area and Poole ; METALLURGISTS for Rosyth and Poole ; CHEMISTS (Physical and Inorganic) for Poole and Baldock. Candidates must normally be natural born British subjects of natural born British parents, with at least First or Second Class Honours Degrees or equivalent high professional attainments. S.S.O.s must have had at least three years' post-graduate experience and be 26 years of age. Salaries (men), S.S.O., £1190–£1410 ; S.O., £635–£1110 (London)—somewhat lower in provinces. Appointments are unestablished (with F.S.S.U. benefits), but opportunities may occur for those under 32 to compete for established posts.—Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting A.98/8A.
E6550

MID-NORTHAMPTONSHIRE WATER BOARD

DEPUTY ENGINEER AND MANAGER

The Board invite applications for the post of DEPUTY ENGINEER AND MANAGER.

Candidates should be Corporate Members of the Institution of Water Engineers and should have had considerable experience of modern waterworks practice.

The Board have an area of supply of 500 square miles with a population of 300,000 persons.

The appointment is subject to the Superannuation Acts, and the salary is £1550 by £50 to £1750.

A house is available, and may be rented from the Board.

Applications should include the names of two referees, and should be sent to the undersigned not later than 1st May, 1958.

LEONARD H. BROWN,
Engineer and Manager.
Cliftonville, Northampton.
E6741

Classified Advts. continued on page 132

PUBLIC APPOINTMENTS

NATIONAL COAL BOARD

RECONSTRUCTION DEPARTMENT

WINDING ENGINEER

WINDING ENGINEER required in Winding Section of N.C.B.'s Reconstruction Department in London. Duties of the Section embrace all matters connected with colliery winding engines and include technical and economic analyses of winding problems associated with new collieries and reconstructions, sinking winders and standardisation of winding engines and allied equipment. Wide experience of this type of work is required, with appropriate academic, professional or technical qualifications. Appointment (superannuable) according to qualifications and experience within inclusive range £1350–£1964.—Write, stating age, education, qualifications, and experience, to Staff Department (X.1052/2), National Coal Board, Hobart House, London, S.W.1, before 24th April, 1958. E6781

COUNTY BOROUGH OF EAST HAM

ASSISTANT ENGINEER (MECHANICAL) GRADE II

ASSISTANT ENGINEER (MECHANICAL), Grade II, £725–£845.

London Weighting is paid in addition. Salary in excess of the minimum may be paid, according to qualifications and experience.

A subsistence allowance may be granted over a reasonable period to the person appointed if unable to obtain suitable housing accommodation, necessitating the maintenance of two homes.

Further details and application forms returnable by 25th April, 1958, from the Town Clerk, Town Hall, E.6. E6745

CHELMSFORD CORPORATION WATERWORKS

SUPERINTENDENT (A.P.T. II. £725–£845)

To take charge of diesel, electrical and pumping plant, sources, workshops, establishments, &c. Further particulars and application form from Engineer and Manager, Hall Street, Chelmsford. Transport and housing available. Closing date, Friday, 25th April, 1958.

B. A. FRANCIS,
Town Clerk.

2nd April, 1958. E6796

TENDERS

CARMARTHEN RURAL DISTRICT COUNCIL

SAINT ISHMAEL WATER AUGMENTATION SCHEME

The Council invite TENDERS on a Fixed Price basis from experienced Contractors, for the following WORK :—

The SUPPLYING, EXCAVATING for, LAYING, JOINTING, MAINTENANCE and ANCILLARY work of approximately 8300 lin. yards of 4in. dia. Spun Iron Pipes with flexible or lead joints, and 1550 lin. yards of 3in. dia. Spun Iron Pipes with flexible or lead joints.

The general conditions, specification, bill of quantities and form of Tender, may be obtained from the undersigned on receipt of a deposit fee of £3, which sum will be returned on receipt of a bona-fide Tender and all documents supplied.

Tenders in a sealed cover, endorsed " St. Ishmael Augmentation Scheme," and addressed to the undersigned, must be received not later than 10 a.m. on Monday, 5th May, 1958.

The Council do not bind themselves to accept the lowest or any Tender.

JOHN JONES,
Clerk to the Council.

Rural District Council Offices,
Spilman Street,
Carmarthen.
Tel.: 7447/7448.
3rd April, 1958. E6797

FORTH ROAD BRIDGE

FENCING AND BUILDINGS CONTRACT

TENDERS are invited from experienced contractors for the EXECUTION of PRELIMINARY FENCING and BUILDING WORK at Port Edgar and Rosyth in connection with the project, comprising :

(1) Temporary Security Fencing.
(2) Prefabricated Police Offices.
(3) Permanent Trailer Pump House.
(4) Steel-Framed Boat and Timber Store.

Copies of the contract documents and drawings may be obtained from the Consulting Engineers, Messrs. Mott, Hay and Anderson, 14, Melville Street, Edinburgh, 3, on payment of a deposit of £5 by cheque, made payable to the Forth Road Bridge Joint Board. The deposit will be repayable when a bona-fide Tender has been received.

Tenders must be sent in sealed plain cover, marked " Tender for the Forth Road Bridge Buildings Contract," and addressed to the Clerk, The Forth Road Bridge Joint Board, City Chambers, Edinburgh, 1, so as to be received there not later than 12th May, 1958.

The Joint Board do not bind themselves to accept the lowest or any Tender.

W. BORLAND,
Clerk to the Forth Road Bridge Joint Board.

E6769

TENDERS

STAFFORDSHIRE POTTERIES WATER BOARD

BUCKNALL RESERVOIR—CONTRACT NO. 30

The Board invite TENDERS from Civil Engineering Contractors experienced in this class of work, for the CONSTRUCTION of a WATER-TIGHT REINFORCED CONCRETE RESERVOIR of 2,000,000 gallons capacity at Bucknall in the City of Stoke-on-Trent.

The form of Tender, conditions of contract, specification and bill of quantities, may be obtained from the undersigned on deposit of a cheque for five guineas, which will be returned on receipt of a bona-fide Tender not subsequently withdrawn.

Plans of the proposed works may be inspected at the Engineer and Manager's Office.

Two separate Tenders are required :
(1) Tender with Variations in Wages and Materials.
(2) Tender on Fixed Price Basis without any variation being allowed in wages and materials.

The two forms of Tender and annexed documents, completed on the alternative basis mentioned above, must be enclosed in the plain envelope provided, endorsed " Tender for Bucknall Reservoir," and addressed to the Chairman, Staffordshire Potteries Water Board, c/o Engineer and Manager's Office, Albion Street, Hanley, Stoke-on-Trent, and delivered not later than 12 noon on Monday, the 12th May, 1958. The envelope must not bear any name or mark indicating the sender. At the same time copies of the completely priced bills of quantities for each of the alternate basis mentioned above must be delivered in one separate sealed envelope, similarly addressed, within the same time. This sealed envelope must be endorsed " Priced Bills for Bucknall Reservoir " and bear the Tenderer's name.

Tenders which do not comply with the above requirements will not be considered.

The Board do not bind themselves to accept the lowest or any Tender.

C. V. BROWN, M.I.C.E., M.I.Mech.E., M.I.W.E.,
Engineer and Manager and Clerk.

Albion Street,
Hanley,
Stoke-on-Trent. E6800

INDIA STORE DEPARTMENT

FOUR LATHES

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :—

4 LATHES for : (1) Grooving and Waving.
(2) Copper Band Turning for 37mm. and 75mm. shot, as shown on drawings available.

Machines are to be similar to the Canadian Hepburn Patent Single Purpose Machines, Size A.

Forms of Tender, which are returnable by Thursday, 5th June, 1958, may be purchased at the above address at a cost of 10s.

In your application for Tender forms, please quote reference 2082/57/SSB/ENG.3. E6747

CITY AND COUNTY OF KINGSTON UPON HULL

SECOND-HAND HYDRAULIC EQUIPMENT

The Property and Bridges Committee is prepared to receive TENDERS for the SUPPLY of SECOND-HAND HYDRAULIC EQUIPMENT generally in accordance with the undernoted specification :—

2 (No.) Hydraulic Accumulators with 12in. cast iron rams suitable for a working pressure of 950 lb. per square inch, each having a working capacity of the order of 50 gallons, complete with ballast box, scrap iron ballast and necessary mountings.

2 (No.) 3-throw Hydraulic Pumps, each capable of delivering approximately 20 gallons of water per minute at 1000 lb. per square inch, direct driven or belt driven from totally enclosed motor arranged for 400 volts, 3 phase, 50 cycles supply.

Offers should be addressed to the City Engineer at the Guildhall, Kingston upon Hull, and should give details of leading dimensions and the site at which the plant may be inspected. Any plant selected for purchase would be required to pass an insurance examination of one of the principal Engineering Insurance Companies prior to purchase. Offers to be addressed to the City Engineer, so as to arrive not later than Monday, 28th April, 1958.

Wm. MORRIS, O.B.E., M.I.C.E., F.R.I.C.S. E6795

INDIA STORE DEPARTMENT

OPTICAL EQUIPMENT FOR LIGHTHOUSES AND LIGHT BUOYS

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of: OPTICAL EQUIPMENT FOR LIGHTHOUSES AND LIGHT BUOYS

Forms of Tender, which are returnable on Monday, 12th May, 1958, may be obtained from this Office (CDN Branch), upon payment of fee of 10s. 0d., which is not returnable. Reference No. 1246/57.Mis.3 must be quoted in all applications. E6755

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent. successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E721 E

EDUCATIONAL

FREE ! Brochure giving details of Courses in Mechanical and Production Engineering, Draughtsmanship, &c., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other professional examinations. —E.M.I. Institutes, Dept. E.30, London, W.4. (Associated with H.M.V. E972 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED

A LARGE INDUSTRIAL ORGANISATION has vacancies for qualified MECHANICAL ENGINEERS, aged 30–35, with good social and educational background, to train as specialists, finally to take charge of staffs in various industrial areas in this country. Reply, stating full details of age, qualifications and experience.—BOX No. E6754, " The Engineer." A

A MARINE ENGINEER is required for work in connection with the application of nuclear energy to marine propulsion. The position is suitable for a man holding a University Degree in Engineering and a Ministry of Transport Certificate would be a distinct advantage. For a considerable period work will be located in the Midlands, where it will be necessary for the successful applicant to live.—Please address applications to The Manager, Marine Propulsion Research Dept., Vickers-Armstrongs (Engineers), Ltd., Barrow-in-Furness, Lancashire. E6704 A

A WELL-ESTABLISHED ENGINEERING COMPANY in the Midlands requires the services of a first-class ENGINEER, having experience in the design and development of packaging machinery to lead a team engaged in this work. Application should be by letter addressed to The Chief Engineer, and should give full details of experience, age and qualifications.—BOX No. E6780, " The Engineer." A

AN ASSISTANT AREA CIVIL ENGINEER is required in the North Staffordshire Area of the West Midlands Divisional Coal Board. Location will be at the Area Headquarters at Stoke-on-Trent.

Salary will be within the range £1050–£1600.

Duties are varied, and include assisting the Area Civil Engineer with the design of civil engineering works associated with colliery reconstruction projects, and the preparation of specifications, contract documents and bills of quantities.

Previous experience in colliery reconstruction schemes an advantage.

Corporate Membership of the Institution of Civil Engineers or Structural Engineers essential.

Applications to Area Staff Manager, National Coal Board, 72, Leek Road, Stoke-on-Trent, by April 29. E6785 A

ALLROUND ENGINEER, 24/30 years, required for position with large group of textile mills in South Africa. Main essentials are experience in plant engineering, not necessarily textiles, but embracing particularly the mechanical and electrical work required in plant engineering. Forceful personality essential. Permanent position carrying good salary, passage paid, house provided if required.—Apply in confidence to BOX No. E1784, " The Engineer." A

ASHMORE, BENSON, PEASE & CO.

(a member of the Power-Gas Group).

HAVE THE FOLLOWING VACANCIES FOR HONOURS GRADUATE MECHANICAL ENGINEERS :—

Assistant Engineers for Engineering Development Section (age 25–28).

Assistant to Chief Production Engineer (age 25–28). These posts arise from the large extension to our works. Join a growing company serving the growing industries of Oil, Chemical, Gas, Iron and Steel and Atomic Energy.

Write for details to the Deputy Managing Director (Works), Stockton-on-Tees. E6756 A

ASHMORE, BENSON, PEASE AND CO., Stockton-on-Tees, require WORK STUDY ENGINEERS to join their production engineering staff. Applicants should be conversant with work study techniques and have experience in applying them to general engineering work in heavy and medium machine shops.—Please reply, stating experience and salary required, to Staff Personnel Manager. E6696 A

BRITISH HYDROCARBON CHEMICALS, LIMITED, GRANGEMOUTH, have vacancies for fully qualified MECHANICAL ENGINEERS, who should either be Graduates or eligible for Associate Membership of the Institution of Mechanical Engineers. Applicants should have completed their National Service and for preference be aged 25 to 35 years. The appointments offer first-class opportunities in a modern and growing industry to ambitious young men and there is a non-contributory pension scheme in operation. Applicants should give full details of background and experience, and all correspondence will be treated in confidence.—Replies, in writing, to the Administrative Officer, British Hydrocarbon Chemicals, Limited, Bo'ness Road, GRANGEMOUTH, Stirlingshire. E6794 A

CHIEF DRAUGHTSMAN required for old-established Midland firm—permanent way engineers. Only men (aged 30–50 years) skilled in knowledge permanent way design and production should apply. State age, experience, salary required. Willing to assist housing finance.—BOX No. E1788, " The Engineer." A

CHIEF DRAUGHTSMAN required for small D.O. of structural and platework engineers. Experience in design of industrial buildings, conveyor gantries, elevators and chutes, coupled with some knowledge of estimating and ability to deal with clients is essential. The position is suitable for a Senior Draughtsman seeking promotion and a planned expansion programme provides real future opportunities. Minimum qualifications H.N.C. Applicants should give age, qualifications, experience, previous employment and salary.—T. Darnell and Sons, Ltd., Colwick Estate, Colwick, Nottingham. E1775 A

CONSULTING CIVIL ENGINEERS immediately require active INSPECTOR for heavy civil engineering work, experience in compressed air necessary, for power station, South Wales.—Telephone L. G. Mouchel and Partners, ABBey 1122. E1758 A

SITUATIONS VACANT

CHIEF DRAUGHTSMAN AND DESIGN ENGINEER required for Blast Furnace Plant, including Coke Ovens and Ancillary Chemical plants. The applicant must be capable of taking charge of drawing-office and outside constructional work. Previous experience in blast furnace engineering an advantage. Age 35–50. This post carries a good salary. Contributory pension scheme.—Write, marking envelope " confidential," giving full particulars of experience and qualifications, to General Manager, Devonshire Works, The Staveley Iron and Chemical Company Limited, Chesterfield. E6735 A

CHIEF ENGINEER

Applications are invited by LAPORTE ACIDS LTD., LEEDS, for the position of Chief Engineer. Candidates must be qualified chemical engineers and preferably have had experience in the field of heavy chemicals, and be 35 years of age or over.

The position carries considerable responsibility, and the successful candidate must be capable of commanding a salary of the order of £2000 p.a.

The Company is a large manufacturer of Sulphuric and Hydrochloric Acids and a range of other products at three works near Leeds. A large programme of development and research in these and other processes is in hand.

A Pension Scheme is in force and in approved cases the Company is also prepared to provide assistance for house purchase and removal expenses.

Applications in writing, giving full details of qualifications and experience and quoting Reference LAL/TE3/6, should be addressed to the Laporte Group Personnel Manager, LAPORTE INDUSTRIES LIMITED, Hanover House, 14, Hanover Square, London, W.1. E6637 A

CIVIL ENGINEER is required as Assistant Resident Engineer on colliery reconstruction scheme. Graduate or exemption from Parts A and B of the Institution's examinations desirable, although a man with suitable experience would be considered. Age 21–30. Apply, with full details in confidence, quoting ref. BU, to BOX No. E6655, " The Engineer." A

CONSTRUCTION SUPERINTENDENT required to take charge of oil storage tank construction at a refinery in the U.K. Previous experience of high quality welding and labour control essential. Applicants should be 30 to 50 and willing to travel anywhere in U.K. Attractive remuneration, permanent appointment and good prospects for the right man.—Apply, giving full details of previous experience, to The Motherwell Bridge and Engineering Co., Ltd., P.O. Box, 4, Motherwell. E6778 A

CONSULTING ENGINEERS require young ENGINEERS in London Office for NUCLEAR PROJECTS. Electrical or Mechanical Degree preferable, experience in power station work desirable. Nuclear training provided if necessary.—Write, KENNEDY and DONKIN (HJP/2), 12, Caxton Street, S.W.1. E6779 A

CONTRACT ENGINEERS.—Vacancies exist in firm of civil engineering designers and contractors for qualified Civil Engineers to act as Contract Engineers. Contracts include erection of reinforced concrete buildings and site and design experience in such work is desirable. Age between 25–35. Salary according to qualifications and experience. These are permanent posts and staff pension and sick pay schemes apply.—Please write, with full details, which will be treated in confidence, to Contract Labour Division, Personnel Department, Simon-Carves, Limited, Cheadle Heath, Stockport. E6654 A

DESIGN/CHECKER STRUCTURAL AND MECHANICAL DRAUGHTSMEN required, South West England. Good conditions, pension scheme.—Apply in confidence to BOX No. E6760, " The Engineer." A

DESIGN/DEVELOPMENT ENGINEERS are required for interesting and varied work with leading commercial vehicle manufacturers engaged on an expansion programme. Apprenticeship in the industry and H.N.C. in Mechanical Engineering are minimum qualifications. Previous experience or qualified M.I.M.E. a distinct advantage. An attractive salary and pension rights are offered. Please forward fullest details in confidence to Company Secretary.—BOX No. E6793, " The Engineer." A

DESIGN DRAUGHTSMEN required, for industrial building work, &c. H.N.C. or A.R.I.B.A. standard. Good conditions, pension scheme.—Apply in confidence to BOX No. E6759, " The Engineer." A

DESIGNER-DRAUGHTSMEN, age 26–40, for work on fuel injection equipment, for high-speed diesel engines, preferably with H.N.C. and at least 5 years' drawing-office experience on injection or other hydraulic equipment. Vacancies are in the North London area, and full details, together with an indication of salary required, should be sent to BOX No. E6786, " The Engineer." A

ELECTRICAL DRAUGHTSMEN required, H.N.C. standard. Fully conversant with motor control gear, A.C. and D.C. E.H.T. and L.T. lighting schemes, &c Good conditions, pension scheme.—Apply in confidence to BOX No. E6757, " The Engineer." A

ELECTRICAL ENGINEER interested in traction, required for interesting job providing quick experience. Applicants should be in 23–35 age group, have good shop experience, and be to Degree standard. Applications will be treated in strict confidence. Write.—BOX No. E1777, " The Engineer." A

SITUATIONS VACANT

ENGINEERING ASSISTANT OR DRAUGHTSMAN required for administrative duties connected with factories with steam process, drying and refrigeration plants. Experience in maintenance of such plant desirable, together with mechanical and electrical engineering qualifications. Ability to conduct technical correspondence and produce reports essential. No age limits, but candidates should be reasonably mobile from base at headquarters of Herring Industry Board, 1, Glenfinlas Street, Edinburgh, 3, to whom they should write fully. E6804 A

ENGINEER (about 30 years) required for Consulting Engineers' Office in Manchester. Technical qualifications should include a Degree and/or Corporate Membership of a major Engineering Institution ; varied industrial experience an advantage. Technical reports following industrial accidents, commenting on safety of method of work, compliance with Statutory Regulations, &c. ; giving evidence in High Court if litigation ensues.—BOX No. E6765, "The Engineer." A

ESTIMATING ENGINEER required for medium/heavy Engineering Works, West Middlesex area Knowledge of Gear Transmission essential. Write, stating age and giving full particulars of qualifications and experience and salary required.—BOX No. E6736, "The Engineer." A

SITUATIONS VACANT

ENGINEER
required in
DEVELOPMENT LABORATORIES
for stress analysis and vibration problems.

Applicants should have a good Degree in Mechanical Engineering, together with ability to make a mathematical approach to problems. Some experience in industry and in the use of electronic equipment is desirable.

The position carries an attractive starting salary and provides excellent opportunities for further advancement. Staff pension fund.

Apply in writing, stating age, qualifications and experience, to the Personnel Manager, JOSEPH LUCAS (ELECTRICAL), LIMITED, Great King Street, Birmingham, 19, quoting reference PM/D/192. E996 A

BOOKS and PUBLICATIONS

FLUID PRESSURE MECHANISMS

By H. G. CONWAY, M.A., A.M.I. Mech.E., etc. 2nd Edition. The new and up-to-date edition of this book deals with the mechanism of fluid pressure equipment and systems, i.e. hydraulic and pneumatic machinery. It deals mainly with the essential principle of the various devices, how they work and how they differ from each other. 32/6 net.

HYDRAULICS AND FLUID MECHANICS

By E. H. LEWITT, B.Sc., Ph.D., etc. 10th Edition. This well-known textbook covers the syllabuses of the B.Sc. (Eng.) and the professional examinations in this subject. In this new edition the book has been completely reset and the material rearranged and in places rewritten, to bring it into line with the revised examination syllabuses in Fluid Mechanics. 37/6 net.

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Telephone: Central 6565

SITUATIONS VACANT

ENGINEERS REQUIRED for a Unilever Company in West Africa for operation and maintenance of (a) vegetable oil producing factory, (b) vegetable oil bulking plant. Candidates, aged 26–33, must be of good education, at least qualified by examination for A.M.I.Mech.E. or equivalent, with good practical operating experience in charge of steam boilers and engines, also diesel engines and plant maintenance, including small electrical installations. Post is one of responsibility for efficient processing, control of staff, training of Africans and sometimes includes upkeep of transport vehicles.—Apply, giving details education, qualifications and experience, to BOX No. E6783, "The Engineer." A

ESTIMATOR REQUIRED in the Engineering Division of British Cellophane, Ltd., Bridgwater, Somerset. Applicants must have served a general engineering apprenticeship, followed by drawing-office experience, and should hold at least an Ordinary National Certificate in Mechanical Engineering ; those with suitable background, but without experience of estimating, would be considered for training. The duties comprise estimating from drawings or from site inspection of the material and labour required for the execution of work on both maintenance and new construction of plant in a chemical factory.—Applications, quoting ref. No. E83 Er., should be addressed to the Personnel Officer. E6703 A

FFESTINIOG PUMPED STORAGE PROJECT

MECHANICAL ENGINEER required for the above contract at Blaenau Ffestiniog, North Wales.

Must have had considerable past experience on major civil engineering contracts, including maintenance and overhaul of 38 and 22 RB excavators, dumpers, Ruston locomotives, Eimco loaders, compressors, drilling equipment, &c.

Reply, stating age and giving full details of past experience, to The Cementation Co., Ltd., 17, India Street, Glasgow, C.2. E1778 A

JACKSON BROS. OF KNOTTINGLEY, LTD.,
require the following :—

1. Young ENGINEER, for maintenance and development work in a modern glass container works. The post is permanent and pensionable and offers scope for further training and advancement. Previous experience in a glass works is not necessary, but successful applicants must have served an engineering apprenticeship, must be either Graduate Members of the I.Mech.E., or studying for this qualification and have had some experience in general works maintenance. Preference will be given to applicants with a knowledge of modern machine shop practice and/or automatic machinery maintenance.
2. SENIOR DRAUGHTSMAN, for work on the design of plant and process equipment in modern glass-producing factory. Previous glass works experience not essential. The applicant should be capable of eventually taking charge of a small drawing-office. State salary required.

All applications should be addressed to Personnel Manager, Jackson Bros. (of Knottingley), Ltd., P.O. Box No. 2, Knottingley, Yorkshire. E6774 A

KUWAIT OIL COMPANY
has a vacancy for a
PETROLEUM ENGINEER
in their
LONDON OFFICE

The Company invites applications for this post from Petroleum Engineers with a minimum of 2 years' oilfield experience and preferably between 25 and 35 years of age.

Salary according to qualifications and experience ; non-contributory pension scheme.

Write for application form, giving brief details and quoting L.O.250 to BOX T/162, c/o 191, Gresham House, E.C.2. E6791 A

JOSEPH LUCAS (ELECTRICAL), LIMITED,
have vacancies for
ASSISTANT DEVELOPMENT ENGINEERS
to work on the design and development of automobile generators, alternators and starting motors and also of motor-cycle electrical equipment, including equipment to be used for racing purposes. Applicants should be of Higher National standard and should have had previous experience in electrical design. Five-day week, staff pension fund.

Apply in writing, stating age, qualifications and experience, to the PERSONNEL MANAGER, JOSEPH LUCAS (ELECTRICAL), LIMITED, Great King Street, Birmingham, 19, quoting reference PM/D/176. E995 A

OLD-ESTABLISHED ENGINEERING CONCERN manufacturing steam specialities, seek active TECHNICAL REPRESENTATIVE to develop country-wide sales in allied and new fields. Practical engineering experience essential, coupled with real ability to create new business. Good starting salary, car and expenses offered initially, further progress depending entirely on the candidate's own ability and initiative.—BOX No. E1763, "The Engineer." A

SITUATIONS VACANT

MECHANICAL ENGINEER interested in traction, required for interesting job providing quick experience. Applicants should be 23–35, have good shop experience and be to Degree or Higher National Certificate standard. Applications will be treated in strict confidence. Write.—BOX No. E1776, "The Engineer." A

MECHANICAL/PIPING DRAUGHTSMEN required, H.N.C. standard. Good conditions, pension scheme.—Apply in confidence to BOX No. E6758, "The Engineer." A

MECHANICAL PLANT ENGINEER, preferably with experience of heavy industry, mechanical handling and services. Age range 30/40. Minimum qualification H.N.C. or equivalent. Commencing salary £900/£1100, according to experience, plus pension scheme after short service.—Write, giving full particulars, to BOX No. E1785, "The Engineer." A

REINFORCED CONCRETE DESIGNERS AND DRAUGHTSMEN are required by large organisation to work in Dorset, South Wales or Manchester areas. Applicants must have sound experience. Salary will be high, together with an expenses allowance if coming from outside the district. Superannuation, excellent conditions.—Apply, giving full particulars of experience and qualifications, to BOX No. E6717, "The Engineer." quoting M.D.I.R. A

SALES ENGINEER required by Yorkshire manufacturer of heavy industrial gears. Must be technically trained at least up to H.N.C. standard. Excellent opportunity for a man with drive, initiative and the right experience. Write, with full details of past career and required salary.—BOX No. E1768, "The Engineer." A

SENIOR DESIGN DRAUGHTSMEN required for interesting work on mechanical engineering projects. Knowledge of hydraulics an advantage.—Chamberlain Industries, Ltd., Staffa Road, Leyton, E.10 (Ley 3678). E6782 A

SENIOR DESIGNERS.—Applications are invited from Senior Designers, experienced in all types of electric cranes, for important work in connection with steel works development schemes. Salaries will be commensurate with responsibilities, and only men of good structural and mechanical training are required.—Write, giving details of age, experience and salary required, to The General Manager, The Wellman Smith Owen Engineering Corporation, Ltd., Darlaston, South Staffs. E6708 A

SENIOR DRAUGHTSMAN required. Medium/heavy engineering experience preferred. Capable of preparing schemes on own initiative. West Middlesex area. Write, stating age and giving full particulars of qualifications, experience and salary required.—BOX No. E6737, "The Engineer." A

SENIOR DRAUGHTSMEN, with general design experience as applicable to iron and steelworks practice, including mechanical handling plant, steel structures and foundry practice. Superannuated post.—Applications, which will be treated in confidence, should state age, technical qualifications and full details of previous experience in chronological order and be addressed to the Staffing Officer, The Stanton Ironworks Company, Limited Near Nottingham. E6803 A

SENIOR JIG AND TOOL DRAUGHTSMAN for engineering company in E. London. Minimum salary £780.—Details of experience and salary required to BOX No. E6805, "The Engineer." A

SENIOR PLANNING ENGINEER required by Midland firm, capable of covering all planning work on special purpose machines. Interesting, permanent position. Superannuation scheme. Salary, £1000 per annum. Apply in confidence for interview.—BOX No. E6768, "The Engineer." A

SEVERAL VACANCIES exist in a factory engaged in the manufacture of glass containers, for ENGINEERS who will be given specialised training for Supervisory positions in Production and Maintenance Departments. A good general engineering background and H.N.C. or equivalent in Mechanical Engineering, are required, but suitably experienced men with O.N.C. now studying for advanced qualifications will also be considered. The positions are covered by the company's staff superannuation scheme and afford a good opportunity for men with initiative and leadership qualities who are prepared to work shifts.—Apply by letter to Personnel Officer, United Glass Bottle Manufacturers Limited, Ravenhead Works St. Helens, Lancashire. E6767 A

STRUCTURAL DESIGNERS, Senior and Junior, required for busy London office handling wide variety building schemes. Considerable scope for advancement available to men of initiative. Consideration given to holiday arrangements.—BOX No. E1782, "The Engineer." A

STRUCTURAL ENGINEERS

Firm of repute, with extensive fabricated steelwork contracts in hand, of versatile nature, have vacancy for ASSISTANT TO MANAGER. Live and ambitious young man wanted who must have undoubted experience and be capable negotiator in all commercial and organising matters in the trade. Technical knowledge valuable asset, but stress laid on ability ensure co-operation and efficiency general operation of business. Four-figure salary ; pensionable ; North West Manchester area. Age limit preferred 35, but others considered if ability warrants. Full history details, present employment and status, with proof experience, in confidence. —BOX No. E1786, "The Engineer." A

TECHNICAL ASSISTANT wanted by firm of chartered patent agents. At least C.I.P.A. Intermediate Standard. Starting salary £1100. University technical qualifications preferred.—Please apply, giving full particulars, to BOX No. E6776, "The Engineer." A

TECHNICAL SALES/COMMERCIAL REPRESENTATIVE required to be peripatetic lightly based on London by widely general engineers. Engineering background important, whole-time energetic interest, personal attributes and ability to earn four-figure salary paramountly important. Generous salary, superannuation and certified expenses offered. Applicants should be between 35 and 45 and should give fullest particulars of career, education and familiarity with such work.—BOX No. E1759, "The Engineer." A

Classified Advts. continued on page 134

SITUATIONS VACANT

TEST ENGINEER, for work in connection with large E.H.V. transformers and associated gear. Experienced man preferred, but training given if background and experience are suitable. Education : H.N.C. (Elec.) standard. Minimum salary £750.—Apply, stating age, experience and salary required, to Fuller Electric, Ltd., Fulbourne Road, E.17.
E6801 A

THE G.K.N. GROUP RESEARCH LABORATORY requires a PHYSICIST or METALLURGIST, preferably with electrical experience, to control projects in the welding field. The post requires a capacity for original work and the exercise of initiative.

The Laboratory serves all the companies of a large group, and is well equipped for fundamental research and development. Ample opportunity exists for contact with Group companies, and research activities are extending.

Applicants, who should be of Degree standard, are assured of good working conditions. Salary scales are attractive.—Please write to the Director of Research, G.K.N. Group Research Laboratory, Birmingham New Road, Lanesfield, Wolverhampton, quoting reference EE/W/4. E6777 A

TONGUE-TIED TECHNICIANS need experienced help when applying for jobs. DRAFTING, ADVICE ON INTERVIEWS, &c. Make the best of yourself and increase your chances.—Ring, UPLands 7663. E1780 A

WELLINGTON TUBE WORKS, LIMITED,
Great Bridge, Tipton

Applications are invited from :

STRUCTURAL DESIGNERS. Minimum qualification H.N.C. Experienced in design of buildings, gantries, towers, &c. Structural design office experience, while essential, need not necessarily be in tube as successful candidates will undergo a period of training.

DRAUGHTSMEN. Minimum qualification O.N.C., or equivalent experience, required for detailing tubular structures.

The structural use of tube is increasing rapidly and these positions offer considerable scope for advancement in an expanding department.

Applications, stating age, qualifications, experience and salary required, should be addressed to "The Secretary." E6792 A

YOUNG METALLURGIST, age 25–30, with H.N.C. or L.I.M. preferred, required by engineering company in South Manchester area, to take charge of laboratories now in course of erection. This appointment offers development work over a broad field and carries excellent superannuation scheme, sports and social facilities and staff canteen. Replies in confidence, stating age, qualifications, experience and salary required.—BOX No. E6802, "The Engineer." A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of an

INDUSTRIAL ENGINEERING MANAGER

for the Midlands headquarters of an engineering group employing over 10,000 in five factories in the U.K., France, and Germany.

He will be responsible to the Director of Manufacturing for advising on work study, cost reduction, establishment of production standards, and incentive payments at each factory.

Candidates should hold a degree or professional qualification in engineering and have had experience in the control of a department responsible for work study and the introduction of wage incentive schemes in a mass-production engineering company. Preferred age 35–40.

Initial salary £2,000 to £2,500 according to experience.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.907, to T. E. Watson.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E6790 A

SITUATIONS VACANT

MECHANICAL ENGINEER

Position available with prominent British Company for young qualified Mechanical Engineer for heavy chemical plant development.

A sound technical background essential and preferably with experience in chemical plant layout and design, with particular reference to mechanical handling. The appointment would be based on London. Good pension scheme and other amenities.

Please reply, giving details of age, qualifications and experience, to BOX No. E6770, "The Engineer." A

SITUATIONS VACANT

BRITISH OXYGEN ENGINEERING LIMITED

invite applications for the position of

PLANT ERECTION ESTIMATOR

The work involves the estimation of labour, transport and erection material costs in connection with enquiries and orders for Industrial Gas and Chemical Plants for United Kingdom and Overseas installations.

A good standard of basic education is required and a Higher National Certificate in Mechanical Engineering or its equivalent would be an advantage.

Excellent salary and conditions of service are offered and HOUSING ASSISTANCE will also be given.

Applications, giving full details of experience, qualifications, age and salary required, should be made to:

Employment Officer,
British Oxygen Engineering Limited
Angel Road, Edmonton, London, N.18.

E6772 A

ENGINEER

for DESIGN ANALYSIS

Engineer required to join a small team concentrating on the advanced design of mechanisms. His duties will include the mathematical analysis of performance, requiring a thorough knowledge of kinematics, the resolution of forces, losses due to friction, surface contact pressures, surface finishes, the effects of impact.

Possession of a Degree with good Mathematical qualification or the equivalent is highly desirable, and a knowledge of and interest in test procedures advantageous.

The location is on the outskirts of Birmingham in pleasant surroundings and on a main bus route, and the salary will be made attractive to a suitably qualified Engineer.

Applications should be addressed to :
Mr. D. N. Walker, Group Chief Engineer,

WILMOT BREEDEN LIMITED
Amington Road, Birmingham, 25.

E6788 A

DISTRICT ENGINEER

required by

CONSULTING CIVIL ENGINEERS

with office in Birmingham. Qualified Engineer fully conversant with modern practice. Age 35 - 45. Write personally in first instance to Mr. Booker.

L. G. MOUCHEL & PARTNERS
36/38 VICTORIA STREET,
WESTMINSTER, S.W.1.

E1787 A

SAFETY OFFICER

required by old-established Engineering Company with headquarters in West London.

Preference will be given to a man of good education who has an engineering background and some knowledge of the Building Industry.

A commencing salary of £900 p.a. is offered and the post is permanent and pensionable.—Apply, BOX No. E6771, "The Engineer." A

SENIOR DRAUGHTSMEN, DESIGN ENGINEERS

and

DESIGN DRAUGHTSMEN

At our Corby Works, one of the largest integrated Iron, Steel and Steel Tube Works in Europe, we have vacancies for MECHANICAL, ELECTRICAL, CIVIL and STRUCTURAL DRAUGHTSMEN.

The vacancies exist in the New Development Drawing-Offices and the Works Drawing-Offices. The work is interesting and offers scope and opportunity to talented young men.

Applicants with Higher National Certificate and experience in either the Iron and Steel industry or heavy engineering are preferred, but men with Ordinary level and relevant experience, or even unqualified men whose experience is outstanding, would be considered.

In addition to these vacancies, there are openings in other Drawing-Offices elsewhere in the Company.

Five-day week. Good welfare, canteen and recreation facilities. Superannuation and life assurance scheme. Staff hostel for single men. Favourable local housing conditions.

GOOD SALARIES BASED ON EXPERIENCE AND QUALIFICATIONS.

Applications will be treated as confidential and should be made, giving details of age, qualifications, experience, and salary required, to :

Manager/Personnel,
STEWARTS AND LLOYDS, LIMITED,
CORBY, Northants.

E11 A

WELDING ENGINEERS

A large Company continuously engaged on major expansion projects has TWO interesting vacancies for Welding Engineers.

(1) WELDING ENGINEER FOR GENERAL WORKSHOP

The general workshop employs 1100 men of whom 45 are welders. The Welding Engineer will be required to control welding procedures and techniques and to establish and run a system of weld inspection. Materials such as mild, low alloy and stainless steels, aluminium and copper base alloys are used in component fabrication. Further development work on automatic and semi-automatic equipment requires to be done.

Applicants should have had considerable practical welding experience and have reached at least H.N.C. level, with suitable endorsements in metallurgy. An engineering Degree would be preferable.

(2) WELDING ENGINEER FOR CONSTRUCTION DEPARTMENT

The Welding Engineer will be responsible for the quality control of site welding on structures, pipe-work and vessels in aluminium and in mild and alloy steels erected by contract or by the Company's direct labour. He will assist in the development of appropriate welding techniques for new alloys, will maintain liaison with the Company's Metallurgical Department and will supervise the site welding inspectors.

Candidates must have been concerned with the practical application of welding, be accustomed to control of labour and have some metallurgical qualification as evidence of technical competence. The work is primarily in one area.

Starting salaries of up to £1300 p.a. are envisaged, dependent on age, qualifications and experience. The appointments are pensionable. The Company, which is a large one, is noted for its progressive staff policy and its welfare and social facilities.

Write, giving brief details of age, qualifications and experience, quoting reference W/P/8. to BOX No. E6762, "The Engineer." A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

CHEMICAL ENGINEER
as
DEVELOPMENT MANAGER

for a British-owned international group with wide interests in the chemical process industry.

This is attractive to a chemical engineer between 35 and 40, with a creative turn of mind allied to an interest in commercial application. He must have had design experience, as well as works experience, preferably as a manager.

He will take charge of a new unit being formed in the Lancashire area to develop new processes and new products, which will extend the Group's activities into other profitable fields.

Starting salary £3,000 with usual benefits.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.923, to J. E. V. Tyzack.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.
E6744 A

SITUATIONS VACANT

DESIGN ENGINEERS

required by progressive company for work in the low-temperature gas separation field. Engineers are required from all branches of chemical engineering, but particularly those experienced in mechanical and piping design. Progressive positions available for the right men. Comprehensive superannuation scheme.— Replies to the Technical Manager, Air Products (Great Britain), Limited, 9, Upper Belgrave Street, S.W.1.

E1779 A

SITUATIONS VACANT

THE REED PAPER GROUP

has a vacancy for a

STEAM AND POWER ENGINEER

at Empire Paper Mills, Ltd., Greenhithe, Kent.

Duties : Responsible for the operation and maintenance of a modern oil-fired Boiler Plant, Power Plant and Steam services throughout the Mill.

Experience : Previous operational experience of similar Boiler and Power Plant essential.

Qualifications : At least H.N.C. or equivalent.

Good commencing salary, non-contributory Pension and Assisted House Purchase Schemes, Canteen, Sports and Social Club. Holiday this year.

Applications in writing, stating age, qualifications, and experience, to Personnel Officer, Empire Paper Mills, Ltd., Greenhithe, Kent, quoting ref. SP/I, by 21st May, 1958.

E6753 A

SITUATIONS VACANT

WORKS MANAGEMENT

DEPUTY WORKS MANAGER

required for a Heavy Engineering Establishment of 1000 employees in Glasgow.

Applicants, preferably 35 to 40 years of age, must be British born Nationals having H.N.C. as minimum qualification and comprehensive experience in production, planning, progressing, works administration and all that Works Management implies.

There is a contributory pension scheme and the post carries an attractive starting salary, commensurate with qualifications and experience, with scope for future advancement for the man of energy and ability.— Write, with full details of qualifications, experience, positions held, &c., in confidence, to BOX " N.B.," c/o. J. W. Vickers & Co., Ltd., 7, Great Winchester Street, London, E.C.2.

E6743 A

ENGINEERS FOR MANAGEMENT

- Applications are invited from men aged 30–35, with either a Mechanical Engineering Degree or A.M.I.Mech.E., whose experience has included contact with some form of industrial process work, either in a supervisory or technical capacity.
- The main qualities sought in candidates are adaptability, a keen brain and the ability to organise and weld groups of technicians, shop supervisors and operators into a highly efficient team.
- If you think this may be the opportunity you are seeking, do not let possible housing problems deter you.
- Applications, which will be treated in strict confidence, should state all the facts which you would wish to know if you were the recipient.

Please write to (Mr.) A. C. McCombie c/o

MICHELIN TYRE CO. LTD., STOKE-ON-TRENT

quoting reference TS.3/E.

E6430 A

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There is a sound and promising future, with the opportunity for really advancing your career; there are attractive salaries and liberal personnel benefits, security and a congenial working atmosphere at Kellogg, the leading design and construction engineers to the petroleum and petro-chemical industries. We are continually expanding and our knowledge and high standard of engineering work can help in your development.

Our Piping Designer-Draughtsmen are of a high standard and we therefore can consider only men of equal calibre. If you qualify and are interested, please write to, or telephone, the Personnel Manager,

KELLOGG **INTERNATIONAL CORPORATION**

7-10 CHANDOS ST., LONDON, W.1.
Telephone: MUSeum 4010
quoting reference 128/G

E6789 A

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DESIGN & DEVELOPMENT ENGINEERS
DRAUGHTSMEN
DEVELOPMENT ASSISTANTS

for vacancies in the design and development of :

INDUSTRIAL PROCESS EQUIPMENT
MARINE NAVIGATIONAL AIDS & AUTO-PILOTS
AERO INSTRUMENTS & FLYING CONTROLS
GUIDED WEAPON COMPONENTS & CONTROL SYSTEMS

Applications, or requests for further information are invited from Engineers and Physicists with an Hons. Degree or equivalent for senior and intermediate level posts and those who have H.N.C. or O.N.C. for Assistant and Drawing Office Posts. The rewards are hard, interesting work and a good salary reviewed annually. Posts based at Brentford, Middx., and Bracknell, Berks., a new town where housing is available in approved cases.

Write in confidence to Mr. R. W. H. Lubbock, B.Sc., SPERRY GYROSCOPE CO. LTD., Bracknell, Berks.

E6748 A

PLOWRIGHT Brothers Limited

Engineering Division

offer an appointment in the Chief Engineer's Department to a suitably qualified person having several years' experience in Mechanical Handling Equipment as applied to Steelworks.

He should be capable of working on his own initiative, be in the 30/40 age group, have served a recognised Engineering Apprenticeship and have at least the H.N.C. in Mechanical Engineering.

The appointment offered carries a good progressive salary, Pension and Life Assurance Scheme and excellent opportunities for advancement.

Write in first instance, giving full details of training and experience, to :—
Chief Engineer, Ref. S.W.E./C.E.,
Brampton Manor,
Chesterfield.

E6618 A

NUCLEAR POWER STATIONS

PRESSURE VESSEL ENGINEERS AND DRAUGHTSMEN

Applications are invited for the following appointments in the

ATOMIC ENERGY DIVISION
OF
THE GENERAL ELECTRIC COMPANY LIMITED

1. PRESSURE VESSEL ENGINEERS

Applicants should have design experience on pressure vessels for the refinery or chemical industries, and should be conversant with the various codes of practice. Shop fabrication or site erection experience would be an advantage. Minimum qualifications H.N.C.

Duties would include the development of designs, from initial concept to fabrication stage, of the numerous pressure vessels which are required in this field for power stations and research projects. Some of these vessels are the largest and most complex of their kind and require the careful solution of many novel problems.

2. SENIOR DRAUGHTSMEN

Applicants should be experienced in pressure vessel work, preferably with some design experience. Minimum qualifications O.N.C.

Work involves the preparation and checking of layout and design drawings and the checking of fabrication drawings. The scope of the work is similar to that mentioned in 1. Suitable applicants will be required to undertake a certain amount of design work.

The above posts provide opportunities for advancement in a rapidly expanding industry, and attractive salaries will be offered to suitable applicants.

Applications should be sent to The Personnel Manager (A.E.D.), The General Electric Company, Limited, Erith, Kent. Telephone : ERITH 3011, Extension 200.

Appointments for interview may also be made by telephone, and these may possibly be arranged in London, Manchester, Newcastle or Glasgow. Housing assistance may be given to suitable applicants and removal expenses will be paid. Holiday arrangements already made will be honoured.

E6775 A

SITUATIONS WANTED

ENGINEER (36), works apprentice, project design, estimating for mechanical and chemical installations, desires position with London company, preferably in Commercial field, where previous engineering experience would be useful. Present salary £1150.—BOX No. E1771, " The Engineer." B

ENGLISH DESIGNER/DRAUGHTSMAN available. 12 years' experience plant layout, vessel design and piping in chemical and petroleum field. Squad leader and site work, plus supervision of pipework erection. Will work 18 months on fixed salary in exchange for passage to England.—Vout, 3366, Templeton, Vancouver 12, B.C., Canada.

E1790 B

FOR HIRE

LATTICE STEEL Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1 ('Phone, SLOane 5259). E112 K

BUSINESS OPPORTUNITIES

HIGHLY REPUTABLE ENGINEERING FIRM, old established, and contractors to H.M. Government, have capacity available for, preferably, complete Manufacture of Additional Line, or, alternatively, Sub-Contract Work involving Grey Iron Castings up to 1 ton weight. Own pattern, foundry, machining and assembly shops. Manufacture under licence or royalty considered.—BOX No. E1591, " The Engineer." O

PATENTS

THE PROPRIETOR of British Patent No. 724,589, entitled " Unitary Shaft Sealing Devices," offers same for Licence or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, 14, E. Jackson Boulevard, Chicago, 4, Illinois, U.S.A. E6738 H

THE PROPRIETOR of British Patent No. 724,592, entitled " AUTOMATIC PARKING METER," offers same for Licence or otherwise, to ensure practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, 14 E, Jackson Blvd., Chicago 4, Illinois, U.S.A. E6731 H

MISCELLANEOUS

TIME RECORDERS, Sales, Rentals, Service, Telephone Hop 2239.—Time Recorder Supply and Maintenance Co., Ltd., 157-159, Borough High Street, London, S.E.1. E608 I

Classified Advts. continued on page 136

AGENCIES

ENGINEERS AND AGENTS well-established in London and South Eastern Counties, with sound export connection, require One or perhaps Two additional AGENCIES. Qualified and energetic team not afraid of a difficult task from Principals of repute if the long-term prospects are good and the product first-class.—BOX No. E6730, "The Engineer." D

FRENCH FIRM requires exclusive Agent, well-introduced in Mechanic, Aircraft and Motor-car factories.—BOX No. E1789, "The Engineer." D

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DRAWING AND DESIGN SERVICE.—Design and Development work required (London), for chemical and industrial plant equipment, special purpose machines, jigs and tools.—BOX No. E1720 "The Engineer" s

60 ROLLS U.2I-sI Black Line Med. Paper, 6s. each. Self-Seal Wage Packets, 18s. 1000.
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E1781 s

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SECOND-HAND HERBERT 2S TURRET LATHE, maximum price £75.0.0.—BOX No. E6777, "The Engineer." F

USED CHURCHILL UNIVERSAL GRINDING MACHINE, minimum capacity 15in. swing by 36in.—BOX No. E6778, "The Engineer." F

WANTED, Machines of all Types
CASH PAID.
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E123 F

WANTED, Tube Expanding Machine, Tube Cleaning Machine, 6in. to 8in. Screwing Machine, with collapsible head.—Fred Watkins (Boilers), Ltd., Coleford, Glos. E997 F

WANTED—Second-hand, Good Condition, or Reconditioned, 10ft. Vertical Boring and Turning Mill.—BOX No. E6799, "The Engineer." F

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NORTH WESTERN GAS BOARD
LIVERPOOL GROUP

The Liverpool Group of the North Western Gas Board has for disposal a Geared Turbo-Alternator/D.C. Generator.

Makers: Turbine—Belliss & Morcom.
Gear Box—David Brown.
Alternator and Generator—Mather & Platt.

Capacity: Alternator—1250kW. M.C.R. at 400V., 50 c., 3 ph., 0·8 p.f.
Generator—300kW. M.C.R., 220/240V., D.C., mounted in tandem.

Steam Conditions: 167 lb. per sq. inch at 500 deg. Fah.
Complete with condenser, air pump, condensate pump and all fittings.

The whole plant was completely overhauled by the makers in 1948/49 and has never been used since.

It can be inspected by appointment, on writing to W. S. Hubbard, Esq., M.I.Mech.E., M.Inst.Gas E., A.M.C.T., Production Engineer, North Western Gas Board, Liverpool Group, Radiant House, Bold Street, Liverpool, 1. E6750 G

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BY ORDER OF THE MINISTER OF SUPPLY

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MACHINE TOOLS

The Minister of Supply offers for SALE BY TENDER MACHINE TOOLS by leading British and Continental makers, including the following:—

Adcock and Shipley, Corona, Holroyd, Jones and Shipman, Leland Gifford and Pollard Drilling Machines.
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Pegard and Olivetti Production Milling Machines.
Hey Duplex Spline Milling Machines.
G.S.P. and Butler Slotting Machines.
Heller and Clifton & Baird Cold Saws.
Brinell Hardness Testing Machines.
Honing, Rifling, Screwing, Tapping and Reaming Machines, Thread Millers, Bench Grinders, Spot Welder, &c.

All the machine tools are lying at Dowlais, Glamorganshire.

Application for Tender forms should be made as soon as possible to the Ministry of Supply, Disposals 2(b), Room 621, First Avenue House, High Holborn, London, W.C.1.

Tender forms will contain descriptions of the machine tools, location in full, and the conditions of sale under which they are offered.

Offers are invited for single machines.

The final date for the receipt of Tenders will be 6th May, 1958. E6776

600

STEAM TURBO-ALTERNATOR SETS

3000kW., 6600/3/50, MET.-VICK., Pass-out/Condensing Steam Turbo-Alternator Set, date 1948, designed for 340 p.s.i.g initially, 600 deg. Fah. temperature; also suitable for the following duties:

Output/kW.	Pass-out/lb./hour	Lb Pressure
3000	60,000	40
1800	40,000	110
1800	40,000 double Pass/out at 1000kW., fully condensing.	

2500kW., 440/3/50, B.T.H., speed 3000 r.p.m., 250 p.s.i.g., 630 deg. F., steam consumption approx. 12·8 lb./kW./hr., with surface condenser, circulating pumps, &c. Also suitable for pass-out pressures varying between 18/35 p.s.i.

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¼ cu. yd. Rapier 410 Diesel-driven Excavator with 4-purpose or dragline equipment
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5-ton Morris Versatile Diesel/Elec. Mobile Crane on solid rubber tyres.
5-ton Smith Steam Loco, 4ft. 8½in. gauge, 35ft. jib.
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UNUSED SET OF PLATE BENDING ROLLS, capacity 32ft. by 1in. down to 6ft. by 2½in. mild steel plate; 75 h.p. roll drive, 40 h.p. screw-down; electrics 400/3/50.—BOX No. E6711, "The Engineer." G

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200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.
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CRANES.—Mobile 10-ton Lorain, lorry mounted, 30ft.–70ft. extendable jib; 4-ton Coles Diesel-Electric; 3-ton Jones Super 40 (3); Neals 2-ton Diesel, 20ft. jibs (2); Derrick, 5-ton Butters Electric travelling type, 90ft. jib; 5-ton Wilson Electric, 70ft. jib; 3-ton Rushworth Electric, 65ft. jib; Steam Loco., 18-ton Brownhoist, 50ft. jib; 10-ton Coles, 40ft. jib; 8-ton Wilson, 35ft. jib; 5-ton Smith, 50ft. jib; 5-ton Cowans Sheldon, 50ft. jib; 5-ton Grafton, 38ft. jib; E.O.T Goliath, 40ft. span, 60-ton Clyde, 40-ton Babcock, 10-ton Morris; 10-ton Vaughan, unused, 40-60ft. span; 5-ton Henderson, 24ft. 7½in. span, 1946; 5-ton King 29ft. 3in. span; 2-ton Morris, 18ft. span 2-ton Smith, 34ft. span.
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2.	14×22	040 Barclay	—	160	22
3.	14×22	040 Barclay	—	160	22
4.	14×22	040 Barclay	—	160	22
5.	14×22	040 Barclay	1935	160	22
6.	17×24	040 Bagnall	1934	160	36
7.	17×24	040 Bagnall	1940	160	36
8.	17×24	040 Bagnall	1941	160	36
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"UNION" HORIZONTAL BORING MACHINE Type BFT 100, dia. of spindle 3 15/16in., max. dia. for boring 24in., 18 spindle feeds, complete with electrics.
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		Main Location	*Auctioneers*
April 15–18	**Machine tools, vehicles and miscellaneous stores,** including clothing, hand tools, bell tents, 200 fork lift trucks, etc.	M.O.S. Storage Depot, Royal Arsenal, **Woolwich, London, S.E.18**	**FULLER, HORSEY, SONS & CASSELL** (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)
April 22	**Machine tools and miscellaneous stores,** including M/T spares, clothing, etc.	M.O.S. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
April 29–May 1	**Vehicles and miscellaneous stores,** including clothing, M/T spares, etc.	Central Ordnance Depot, **Bicester, Oxon.**	**MIDLAND MARTS, LTD.** (Dept. L), Market Square, Bicester, Oxon. (Tel.: 73.)
May 7–8	**Machine tools and miscellaneous stores,** including :—	Technical Stores Sub-Depot, **Old Dalby, Melton Mowbray, Leics.** (Sale at Melton Mowbray.)	**SHOULER & SON** (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 81.)
	Centre and precision lathes, toolroom grinders, blanking and piercing, moulding, baling and frame presses, pillar and bench drills, threadmillers, sand drier, arc welders, woodworking machines, engine belting, warehouse platform trucks, cotton sheeting and blanketing, 43,000 gallons paint, 400 tons of dry paint, 25 tons matrix metal, winches, jacks, 15in. lathe chucks and spares, sewing machines, oven tubes, etc.		
May 13–16	**Vehicles, lifting and earth moving equipment, trailers, motor cycles,** etc.	M.O.S. Storage Depot, **Ruddington, Notts.**	**WALKER WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
May 15	**Miscellaneous stores,** including furniture, etc.	General Stores Sub-Depot, **Longtown, Nr. Carlisle.** (Sale at County Hall, Carlisle.)	**HARRISON & HETHERINGTON, LTD.** (Dept. L) Botchergate, Carlisle. (Tel.: 26292/3.)

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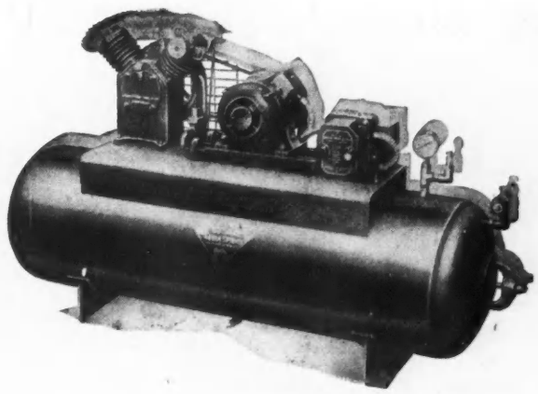

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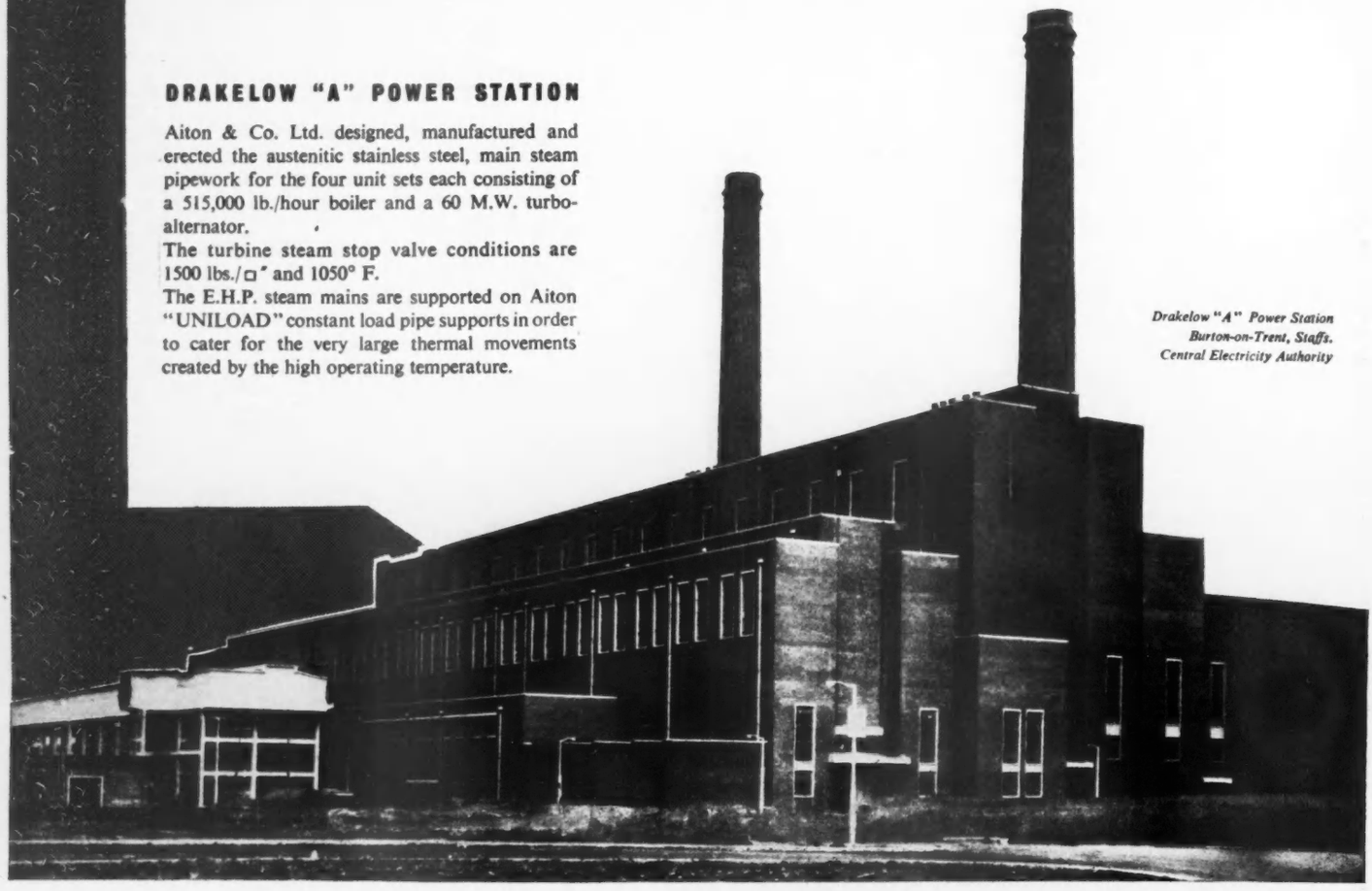

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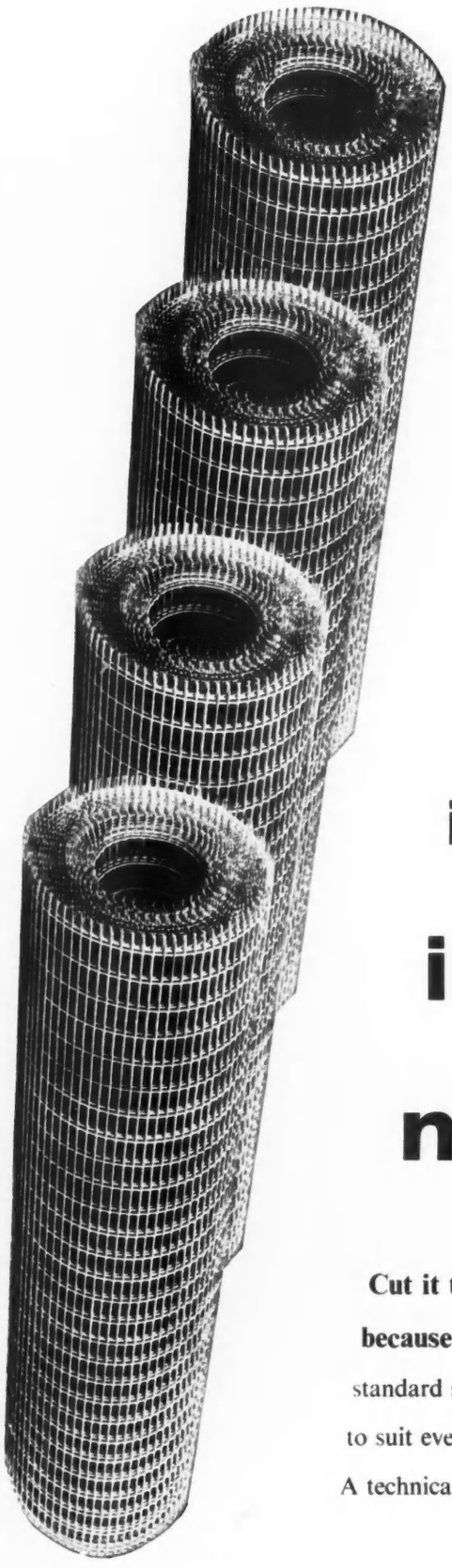

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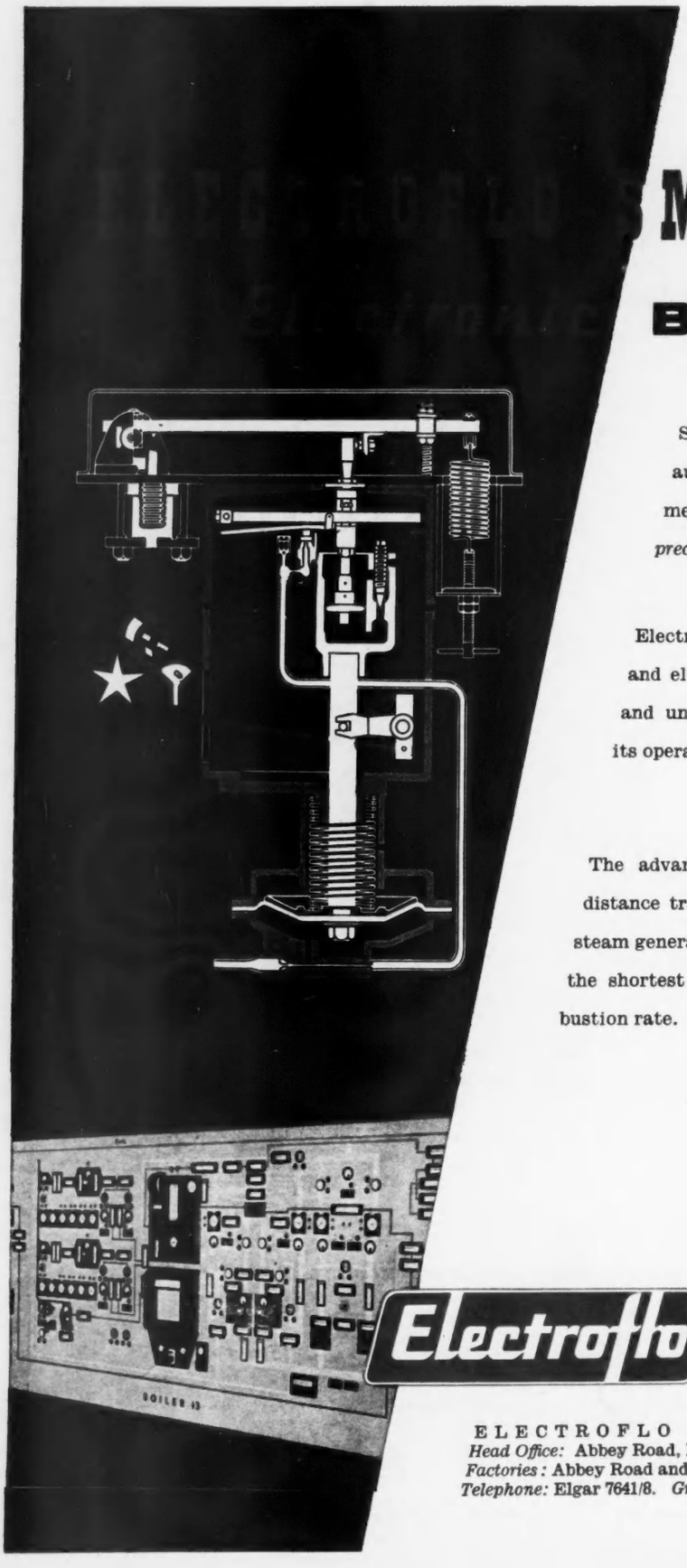

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ELECTROFLO METERS COMPANY LIMITED
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